THIRD AMERICAN EDITION

OF

Nicholson's

BRITISH ENCYCLOPEDIA

or Dictionary of

ARTS & SCIENCES

illustrated by upwards of 180 elegant Engravings.

PHILADELPHIA.

Published by Mitchell Ames & White.

W. Brown Printer.

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BRITISH ENCYCLOPEDIA,

OR

DICTIONARY

OF

ARTS AND SCIENCES,

COMPRISING

AN ACCURATE AND POPULAR VIEW

OF THE PRESENT

IMPROVED STATE OF HUMAN KNOWLEDGE.

BY WILLIAM NICHOLSON,

Author and Proprietor of the Philosophical Journal, and various other Chemical, Philosophical, and Mathematical Works.

ILLUSTRATED WITH

UPWARDS OF 180 ELEGANT ENGRAVINGS.

VOL. V.

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ELLIPSIS.

ELLIPSIS, in geometry, a curve line returning into itself, and produced from the section of a cone by a plane cutting both its sides, but not parallel to the base. See CONIC SECTIONS.

The easiest way of describing this curve, in plano, when the transverse and conjugate axis A B, E D, (Plate V. Miscell. fig. 1.) are given, is this: first take the points F, f, in the transverse axis A B, so that the distances C F, C f, from the centre C, be each equal to $\sqrt{AC - CD}$; or that the lines F D, f D, be each equal to A C: then, having fixed two pins in the points F, f, which are called the foci of the ellipsis, take a thread equal in length to the transverse axis A B; and fastening its two ends, one to the pin F, and the other to f, with another pin M stretch the thread tight; then if this pin M be moved round till it returns to the place from whence it first set out, keeping the thread always extended so as to form the triangle F M f, it will describe an ellipsis, whose axes are A B, D E.

The greater axis, A B, passing through the two foci F f, is called the transverse axis; and the lesser one D E, is called the conjugate, or second axis: these two always bisect each other at right angles, and the centre of the ellipsis is the point C, where they intersect. Any right line passing through the centre, and terminated by the curve of the ellipsis on each side, is called a diameter; and two diameters, which naturally bisect all the parallels to each other, bounded by the ellipsis, are called conjugate diameters. Any right line, not passing through the centre, but terminated by the ellipsis, and bisected by a diameter, is called the ordinate, or ordinate-applicate, to that diameter; and a third proportional to two conjugate diameters is called the latus rectum, or parameter of that diameter, which is the first of the three proportionals.

The reason of the name is this: let B A, E D, be any two conjugate diameters of an ellipsis (fig. 2, where they are the two axes) at the end A, of the diameter A B, raise the perpendicular A F, equal to the latus rectum, or parameter, being a third proportional to A B, E D, and draw the right line B F; then, if any point P be taken in B A, and an ordinate P M be drawn, cutting B F in N, the rectangle under the absciss A P, and the line P N will be equal to the square of the ordinate P M. Hence drawing N O parallel to A B, it appears that this rectangle, or the square of the ordinate, is less than that under the absciss A P, and the parameter A F, by the rectangle under A P and O F, or N O and O F; on account of which deficiency, Appollonius first gave this curve the name of an ellipsis, from ελλειπειν, to be deficient.

In every ellipsis, as A E B D, (fig. 2), the squares of the semi-ordinates M P, $m\,p$, are as the rectangles under the segments of the transverse axis $AP \times PB$, $Ap \times pB$, made by these ordinates respectively; which holds equally true of

ELL

the circle, where the squares of the ordinates are equal to such rectangles, as being mean proportionals between the segments of the diameter. In the same manner, the ordinates to any diameter whatever are as the rectangles under the segments of that diameter.

As to the other principal properties of the ellipsis, they may be reduced to the following propositions. 1. If from any point M in an ellipsis, two right lines, M F, M *f*, (fig. 1.) be drawn to the foci F, *f*, the sum of these two lines will be equal to the transverse axis A B. This is evident from the manner of describing an ellipsis. 2. The square of half the lesser axis is equal to the rectangle under the segments of the greater axis, contained between the foci and its verticles; that is, $DC^2 = AF \times FB = Af \times fB$. 3. Every diameter is bisected in the centre C. 4. The transverse axis is the greatest, and the conjugate axis the least, of all diameters. 5. Two diameters, one of which is parallal to the tangent in the vertex of the other, are conjugate diameters; and, *vice versa*, a right line drawn through the vertex of any diameter, parallel to its conjugate diameter, touches the ellipsis in that vertex. 6. If four tangents be drawn through the vertices of two conjugate diameters, the parallelogram contained under them will be equal to the parallelogram contained under tangents drawn through the vertices of any other two conjugate diameters. 7. If a right line, touching an ellipsis, meet two conjugate diameters produced, the rectangle under the segments of the tangent, between the point of contact and these diameters, will be equal to the square of the semi-diameter, which is conjugate to that passing through the point of contact. 8. In every ellipsis, the sum of the squares of any two conjugate diameters is equal to the sum of the squares of the two axes. 9. In every ellipsis, the angles F G I, *f* G H, (fig. 1), made by the tangent H I, and the lines F G, *f* G, drawn from the foci to the point of contact, are equal to each other. 10. The area of an ellipsis is to the area of a circumscribed circle, as the lesser axis is to the greater, and *vice versa* with respect to an inscribed circle; so that it is a mean proportional between two circles, having the transverse and conjugate axes for their diameters. This holds equally true of all the other corresponding parts belonging to an ellipsis.

The curve of any ellipsis may be obtained by the following series. Suppose the semi-transverse axis $CB = r$, the semi-conjugate axis $CD = c$, and the semi-ordinate $= a$; then the length of the curve

$$MB = a + \frac{r^2 a^3}{6c^4} + \frac{4 r^2 c^2 a^5 - r a^5}{40 c^8} + \frac{8 c^4 r^2 a^7 + r^6 a^7 - 4 c^2 r^5 a^7}{112 c^{12}}, \text{ \&c.}$$

And if the species of the ellipsis be determined, this series will be more simple: for if $c = 2r$, then

$$MB = a + \frac{a^3}{96 r^2} + \frac{3 a^5}{2048 r^4} + \frac{113 a^7}{458752 a^6} + \frac{3419 a^9}{75497472 r^8}, \text{ \&c.}$$

This series will serve for an hyperbola, by making the even parts of all the terms affirmative, and the third, fifth, seventh, &c. terms negative.

The periphery of an ellipsis, according to Mr. Simpson, is to that of a circle, whose diameter is equal to the transverse axis of the ellipsis, as

$$1 - \frac{d}{2.2} - \frac{3d^2}{2.2.4.4} - \frac{3.3.5d^3}{2.2.4.4.6.6} - \frac{2.3.5.5.7d^4}{2.2.4.4.6.6.8.8}$$

&c. is to 1, where d is equal to the difference of the squares of the axis applied to the square of the transverse axis.

Ellipsis, in grammar, a figure of syntax, wherein one or more words are not expressed; and from this deficiency it has got the name ellipsis.

Ellipsis, in rhetoric, a figure nearly allied to preterition, when the orator, through transport of passion, passes over many things, which, had he been cool, ought to have been mentioned. In preterition, the omission is designed; which, in the ellipsis, is owing to the vehemence of the speaker's passion, and his tongue not being able to keep pace with the emotion of his mind.

ELLIPTIC, or Elliptical, something belonging to an ellipsis. Thus we meet with elliptical compasses, elliptic conoid, elliptic space, elliptic stairs, &c. The elliptic space is the area contained within the curve of the ellipsis, which is to that of a circle described on the transverse axis, as the conjugate diameter is to the transverse axis; or it is a mean proportional between two circles, described on the conjugate and transverse axis.

ELLIPTOIDES, in geometry, a name used by some to denote infinite ellipses, defined by the equation $ay^{m+n} = bx^m (a-x)^n$.

Of these there are several sorts: thus, if $a\,y^3 = b\,x^2\,(a-x)$ it is a cubical eliptoid; and if $a\,y^4 = b\,x^2\,(a-x)^2$, it denotes a biquadratic elliptoid, which is an ellipsis of the third order in respect of the appollonian ellipsis.

ELLISIA, in botany, so called in memory of John Ellis, F. R. S. a genus of the Pentandria Monogynia class and order. Natural order of Luridæ. Borragineæ, Jussieu. Essential character: corolla funnel-form, narrow; berry dry, two-celled, two valved; seeds two, dotted, one placed over the other. There is only one species, *viz.* E. nyctelea, cut-leaved ellisia, a native of Virginia.

ELM. See ULMUS. The elm is very serviceable in places where it may lie continually dry or wet in extremes. Accordingly, it is proper for water-works, mills, the ladles and soles of the wheel-pipes, pumps, aqueducts, pales, and ship-planks beneath the water-lines. It is also of use for wheel-rights, handles for single saws, axle-trees, and the like. The clearness of the grain makes it also fit for all kinds of carved works, and most ornaments relating to architecture.

ELOCUTION, in rhetoric, the adapting words and sentences to the things or sentiments to be expressed. It consists of elegance, composition, and dignity. The first, comprehending the purity and perspicuity of language, is the foundation of elocution. The second ranges the words in proper order; and the last adds the ornaments of tropes and figures, to give strength and dignity to the whole.

ELOGY, a praise or panegyric bestowed on any person or thing, in consideration of its merit. The beauty of elogy consists in an expressive brevity. Elogiums should not have so much as one epithet, properly so called, nor two words synonimous. They should strictly adhere to truth; for extravagant and improbable elogies rather lessen the character of the person or thing they would extol.

ELONGATION, in astronomy, the digression or recess of a planet from the sun, with respect to an eye placed on our earth. The term is chiefly used in speaking of Venus and Mercury, the arch of a great circle intercepted between either of these planets and the Sun being called the elongation of that planet from the Sun.

But here it is to be observed, that it is only a circle which has the sun for its centre; that the greatest elongation is in a line touching the planet's orbit. For in an elliptic orbit it may be, that the elongation from the sun may grow still greater, even after it has left the place where the line joining the earth and planet touches the orbit. For after that, the true distance of the planet from the Sun may increase, whilst the distance of the Sun and planet from the earth does not increase, but rather decrease. But because the orbits of the planets are nearly circular, such small differences may be neglected in astronomy. The greatest elongation of Venus is found by observation to be about forty-eight degrees, and the greatest elongation of Mercury about twenty-eight degrees, upon which account this planet is rarely to be seen with the naked eye.

ELONGATION, *angle of,* is an angle contained under lines drawn from the centre of the sun and planet to the centre of the earth.

ELOPEMENT, is when a married woman of her own accord departs from her husband, and dwells with an adulterer; for which, without voluntary reconciliation to the husband, she shall lose her dower by the statute of Westminster, 2. c. 34. Except that her husband willingly, and without coercion of the church, reconcile her, and suffer her to dwell with him, in which case, she shall be restored to her action, 13 Ed. I. st. 1. c. 34. By eloping in this manner, or living in adultery apart from the husband, he is discharged of her future debts, and no longer liable to support her.

ELOQUENCE, the art of speaking well, so as to affect and persuade. Cicero defines it the art of speaking with copiousness and embellishment. Eloquence and rhetoric differ from each other, as the theory from the practice; rhetoric being the art which describes the rules of eloquence, and eloquence that art which uses them to advantage. See RHETORIC.

ELOPS, in natural history, a genus of fishes of the order Abdominales. Generic character: head smooth, edges of the jaws and palate rough, with teeth; gill membrane with thirty rays, and armed on the outside in the middle with five teeth. The saury elops, the only species, bears a considerable resemblance to a salmon, from which it differs principally in wanting the fleshy back fin. It inhabits the shores of Carolina and the West Indies; in Jamaica it passes by the name of the sun-fish. It is in general about fourteen inches long.

ELYMUS, in botany, *lymegrass,* a genus of the Triandria Digynia class and

order. Natural order of Gramina, or Grasses. Essential character: calyx lateral, two-valved, aggregate, many flowered. The American species are 10 in number. *viz.* 1. E. arenarius. 2. E. philadelphicus. 3. E. canadensis. 4. E. virginicus. 5. E. striatus. 6. E. europæus, 7. E. villosus. 8. E. hystric. 9. E. ciliatus. 10. E. glaucifolius. (*Muhl.*)

EMARGINATED, among botanists, an appellation given to such leaves as have a little indenting on their summits: when this indenting is terminated on each side by obtuse points, they are said to be obtusely emarginated; whereas, when these points are acute, they are called acutely emarginated.

EMBALMING, is the opening a dead body, taking out the intestines, and filling the place with odoriferous and desiccative drugs and spices, to prevent its putrefying. The Egyptians excelled all other nations in the art of preserving bodies from corruption; for some that they have embalmed upwards of 2000 years ago remain whole to this day, and are often brought into other countries as great curiosities. Their manner of embalming was thus; they scooped the brains with an iron scoop out at the nostrils, and threw in medicaments to fill up the vacuum: they also took out the entrails, and having filled the body with myrrh, cassia, and other spices, except frankincense, proper to dry up the humours, they pickled it in nitre, where it lay soaking for seventy days. The body was then wrapped up in bandages of fine linen and gums, to make it stick like glue; and so was delivered to the kindred of the deceased, entire in all its features, the very hairs of the eye-lids being preserved. They used to keep the bodies of their ancestors, thus embalmed, in little houses magnificently adorned, and took great pleasure in beholding them alive, as it were, without any change in their size, features, or complexion. The Egyptians also embalmed birds, &c. The prices for embalming were different; the highest was a talent, the next 20 minæ, and so decreasing to a very small matter; but those who had not wherewithall to answer this expense, contented themselves with infusing, by means of a syringe, through the fundament, a certain liquor extracted from the cedar, and, leaving it there, wrapped up the body in salt of nitre: the oil thus preyed upon the intestines, so that, when they took it out, the intestines came away with it, dried, and not in the least putrefied: the body, being inclosed in nitre, grew dry, and nothing remained besides the skin glued upon the bones.

The method of embalming used by the modern Egyptians, according to Maillet, is, to wash the body several times with rose-water, which, he elsewhere observes, is more fragrant in that country than with us. They afterwards perfume it with incense, aloes, and a quantity of other odours, of which they are by no means sparing; and then they bury the body in a winding-sheet, made partly of silk and partly of cotton, and moistened, as is supposed, with some sweet-scented water or liquid perfume, though Maillet uses only the term moistened; this they cover with another cloth of unmixed cotton, to which they add one of the richest suits of clothes of the deceased. The expense, he says, on these occasions, is very great, though nothing like what the genuine embalming cost in former times.

EMBARGO, in commerce, an arrest on ships, or merchandize, by public authority; or a prohibition of state, commonly on foreign ships, in time of war, to prevent their going out of port; sometimes to prevent their coming in; and sometimes both, for a limited time. The king may lay embargoes on ships, or employ those of his subjects, in time of danger, for service and defence of the nation; but they must not be for the private advantage of a particular trader, or company: and, therefore, a warrant to stay a single ship is no legal embargo. No inference can be made from embargoes which are only in war time, and are a prohibition by advice of council, and not a prosecution of parties. If goods be laden on board, and after an embargo or restraint from the prince or state comes forth, and then the master of the ship breaks ground, or endeavours to sail, if any damage accrues, he must be responsible for the same: the reason is, because his freight is due, and must be paid, nay though the goods be seized as contraband. Embargo differs from quarantine, insomuch as this last is always for the term of forty days, in which persons from foreign parts infected with the plague are not permitted to come on shore. See Quarantine.

EMBASSADOR, or Ambassador, a public minister sent from one sovereign prince, as a representative of his person, to another.

Embassadors are either ordinary or extraordinary. Embassador in ordinary is he who constantly resides in the court of

another prince, to maintain a good understanding, and look to the interest of his master. Till about two hundred years ago, embassadors in ordinary were not heard of; all, till then, were embassadors extraordinary; that is, such as are sent on some particular occasion, and who retire as soon as the affair is dispatched.

By the law of nations, none under the quality of a sovereign prince can send or receive an embassador. At Athens, embassadors mounted the pulpit of the public orators, and there opened their commission, acquainting the people with their errand. At Rome, they were introduced to the Senate, and delivered their commissions to them.

Embassadors should never attend any public solemnities, as marriages, funerals, &c. unless their masters have some interest therein: nor must they go into mourning on any occasions of their own, because they represent the persons of their prince. By the civil law, the moveable goods of an embassador, which are accounted an accession to his person, cannot be seized on, neither as a pledge, nor for payment of a debt, nor by order or execution of judgment, nor by the King's or state's leave where he resides, as some conceive; for all actions ought to be far from an embassador, as well that which toucheth his necessaries, as his person: if, therefore, he hath contracted any debt, he is to be called upon kindly, and if he refuses, then letters of request are to go to his master. Nor can any of the embassador's domestic servants, that are registered in the Secretaries of State's Office, be arrested in person or goods: if they are, the process shall be void, and the parties suing out and executing it shall suffer and be liable to such penalties and corporal punishment, as the Lord Chancellor, or either of the chief justices, shall think fit to inflict. Yet embassadors cannot be defended when they commit any thing against that state, or the person of the prince, with whom they reside; and if they are guilty of treason, felony, &c. or any other crime against the law of nations, they lose the privilege of an embassador, and may be subject to punishment as private aliens.

EMBER *weeks*, or *days*, in the Christian Church, are certain seasons of the year, set apart for the imploring God's blessing, by prayer and fasting, upon the ordinations performed in the church at such times. These ordination fasts are observed four times in the year, *viz.* the Wednesday, Friday, and Saturday, after the first Sunday in Lent, after Whitsunday, after the fourteenth of September, and the thirteenth of December; it being enjoined, by a canon of the church, that deacons and ministers be ordained, or made, only upon the Sundays immediately following these ember fasts. The ember-weeks were formerly observed in different churches with some variety, but were at last settled as they are now observed, by the council of Placentia, anno 1095. The council of Mentz, convened by Charlemagne, mentions the ember-weeks as a new establishment.

EMBERIZA, the *bunting*, in natural history, a genus of birds of the order Passeres. Generic character: bill conic; mandibles receding from each other, from the base downwards; the lower with the sides narrowed in; the upper containing a large knob, of use to break hard seeds. There are, according to Gmelin, seventy-seven species. Latham enumerates sixty-three, of which the most important are the following: E. nivalis, the snow bunting. These birds are about the size of a chaffinch, and have been found in the most northern latitudes to which navigators have penetrated. They are found, not merely on the land about Spitzbergen, but upon the ice contiguous to it, though merely graminivorous birds, of which genus they are the sole species found in that climate. In the north of Great Britian they sometimes appear in vast flocks, and are considered as the harbingers of a severe winter. They are known in Scotland by the name of snow flake. E. hortulana, the ortolan, is somewhat less than the yellow-hammer, is common in France and Italy, in Germany and Sweden. These birds are migratory, and in their passage are caught in vast multitudes, to be fed for the table, being considered as extremely delicate and luxurious food. They are enclosed by professional feeders in dark rooms, where oats, and other grains, and seeds, are provided for them in the fullest abundance. On these articles they feed with such voracity, that in a short time they attain that size, which it is impossible for them to exceed, and constitute, it may almost be said, one mass of exquisitely flavoured and luscious fat. From this state they would soon sink in lethargy, but they are now killed by their owners for the market. A full-fed ortolan weighs about three ounces. It rarely passes farther north than Russia, and is not to be found in England, or the United States. By

many its notes are particularly admired. It sometimes builds on low hedges, and occasionally on the ground, and generally breeds twice a year. E. citrinella, or the yellow hammer, is extremely common in Great Britain, where it lays its eggs on the ground, or in some low bush, constructing it with little art; it possesses no interesting musical tones, and is tame and stupid in its character; it feeds on grain and insects, and is to be found in almost every country in Europe; its flesh in England is generally bitter, but in Italy the yellow hammer is fattened like the ortolan for the table, and is in considerable estimation. E. miliaria, the common bunting. These birds are also particularly common in England, and appear frequently in vast flocks, especially in the winter, during which they are caught in nets, or shot in vast numbers, and sold to many under the successful pretence of their being a species of larks. They are stationary in England, but on the continent are birds of passage. During the incubation of the female, the male is observed frequently on the bare and prominent branch of some neighbouring tree, exerting himself to cheer her confinement by his song, which, however, is harsh and monotonous in the extreme; at short intervals he utters a sort of trembling shriek, several times repeated. E. oryzivora, or the rice bird, is peculiar to America, where its depredations on the rice and maize subject it to the peculiar aversion of the farmer. They are occasionally kept for the sake of their music. They frequent the shores of rivers in the eastern and northern states, during the autumn, in immense flocks, feeding on the seeds of wild rice, or reeds, as they are called in Pennsylvania (Zizania clavulosa). They are then shot in great numbers for the market, are extremely fat and delicious, not inferior to the ortolan. During the season of their loves, the colour of the male differs very considerably from that of the female, but gradually assimilates with it, until, in the autumn, they are almost undistinguishable from each other by colour. Their brumal retreat is unknown. It is, however, far to the south, and perhaps without the boundaries of the United States. For the cirl bunting, see Aves, Plate VI. fig. 4. For the black-head bunting, see Aves, Plate VI. fig. 5.

EMBEZZLEMENT, in law, by stat. 39 Geo. 3. c. 35. for protecting masters against embezzlement by their clerks and servants: servants or clerks, or persons employed for the purpose, or in the capacity of servants or clerks, who shall, by virtue of such employment, receive, or take into their possession, any money, goods, bond, bill, note, banker's draft, or other valuable security or effects, for or in the name, or on the account of, their master or employer; or who shall fraudently embezzle, secrete, or make away with the same, or any part thereof; every such offender shall be deemed to have feloniously stolen the same from his master or employer, for whose use, or on whose account, the same was delivered to or taken into the possession of such servant, clerk, or other person so employed, although such money, goods, bond, bill, note, banker's draft, or other valuable security, was or were no otherwise received into the possession of his or their servants, clerk, or other person so employed; and every such offender, his adviser, procurer, aider, or abetter, being thereof lawfully convicted or attainted, shall be liable to be transported beyond seas.

EMBLEM, a kind of painted enigma, or certain figures painted or cut metaphorically, expressing some action, with reflections underneath, which, in some measure, explain the sense of the device, and at the same time instruct us in some moral truth, or other matter of knowledge. The emblem is somewhat plainer than the enigma, and the invention is more modern, it being entirely unknown to the ancients.

EMBLEMENTS, in law, signify the profits of land sown; but the word is sometimes used more largely, for any profits that arise and grow naturally from the ground, as grass, fruit, hemp, flax, &c.

EMBOLISMIC, or *intercalary*, a term used by chronologists in speaking of the additional months and years which they insert, to bring the lunar to the solar year. Since the common lunar year consists of twelve synodic months, or 354 days nearly, and the solar consists of 365 days (throwing away the odd hours and minutes) it is plain that the solar year will exceed the lunar by about 11 days; and, consequently, in the space of about 33 years, the beginning of the lunar year will be carried through all the seasons, and hence it is called the moveable lunar year. This form of the year is used at this time by the Turks and Arabians; and because in three year's time the solar year exceeds the lunar by 33 days, therefore, to keep the lunar months in

the same seasons and times of the solar year, or near it, chronologists added a whole month to the lunar year every third year, and so made it consist of 13 months; this year they called the embolismic year, and the additional month the embolismic, or embolimean, or intercalary month. This form of the year is called the fixed lunar year, and it was used by the Greeks and Romans till the time of Julius Cæsar.

EMBOSSING, or IMBOSSING, in architecture and sculpture, the forming or fashioning works in relievo, whether cut with a chizzel or otherwise. Embossing is a kind of sculpture, wherein the figures stick out from the plane whereon it is cut; and according as the figures are more or less prominent, they are said to be in alto, mezzo, or basso relievo; or high, mean, or low relief.

EMBOTHRIUM, in botany, a genus of the Tetrandria Monogynia class and order. Natural order of Proteæ, Jussieu. Essential character: corolla four-petalled; anthers sessile, sitting on the tips of the petals; follicle round. There are four species.

EMBRACERY, is an attempt to corrupt or influence a jury, or any way incline them to be more favourable to the one side than the other, by money, promises, letters, threats, or persuasions, whether the juror, on whom such attempt is made, give verdict or not, or whether the verdict given be true or false, which is punished by fine and imprisonment; and the juror taking money, perpetual infamy, imprisonment for a year, and forfeiture of tenfold the value.

EMBRASURE, in fortification, a hole or aperture in a parapet, through which the cannon are pointed, to fire into the moat or field. Embrasures are generally twelve feet distant from one another, every one of them being from six to seven feet wide without, and about three within; their height above the platform is three feet on that side towards the town, and a foot and a half on the other side towards the field; so that the muzzle may be sunk on occasion, and the piece brought to shoot low.

EMBROCATION, in surgery, an external kind of remedy, which consists in an irrigation of the part affected with some proper liquor, as oils, spirits, &c. by means of a woollen or linen cloth, or a sponge, dipped in the same. The use of embrocation is either to attenuate and dislodge something obstructed underneath the skin, to ease pains, or to irritate the part into more warmth and a quicker sense of feeling. The pumping used in natural baths is properly an embrocation.

EMBROIDERY, a work in gold, or silver, or silk thread, wrought by the needle upon cloth, stuff, or muslin, into various figures. In embroidering stuffs, the work is performed in a kind of loom, because the more the piece is stretched, the easier it is worked. As to muslin, they spread it upon a pattern ready designed; and sometimes, before it is stretched upon the pattern, it is starched, to make it more easy to handle. Embroidery on the loom is less tedious than the other, in which, while they work flowers, all the threads of the muslin, both lengthwise and breadthwise, must be continually counted; but, on the other hand, this last is much richer in points, and susceptible of greater variety. Cloths too much milled are scarce susceptible of this ornament, and in effect we seldom see them embroidered. The thinnest muslins are left for this purpose, and they are embroidered to the greatest perfection in Saxony; in other parts of Europe, however, they embroider very prettily, and especially in France.

There are several kinds of embroidery; as, 1. Embroidery on the stamp, where the figures are raised and rounded, having cotton or parchment put under them, to support them. 2. Low embroidery, where the gold and silver lie low upon the sketch, and are stiched with silk of the same colour. 3. Guimped embroidery: this is performed either in gold or silver: they first make a sketch upon the cloth, then put on cut vellum, and afterwards sew on the gold and silver with silk thread; in this kind of embroidery they often put gold and silver cord, tinsel, and spangles. 4. Embroidery on both sides; that which appears on both sides of the stuff. 5. Plain embroidery, where the figures are flat and even, without cords, spangles, or other ornaments.

EMBROIDERY, no foreign embroidery, on gold or silver brocade, is permitted to be imported into this kingdom, on pain of being seized and burned, and a penalty of 100*l.* for each piece.

EMBRYO, in physiology, the first rudiments of an animal in the womb, before the several members are distinctly formed; after which period it is denominated a fœtus. See FŒTUS and MIDWIFERY.

Embryo, in botany. See Corculum.

EMERALD. This mineral comes chiefly from Peru; some specimens have been brought from Egypt. Dolomieu found it in the granite of Elba. Hitherto it has been found only crystallized. The primitive form of its crystals is a regular six-sided prism; and the form of its integrant molecules is a triangular prism, whose sides are squares, and bases equilateral triangles. The most common variety of its crystals is the regular six-sided prism, sometimes with the edges of the prism, or of the bases, or the solid angles, or both, wanting, and small faces in their place.

Crystals short; lateral planes smooth, terminal planes rough; colour emerald green, of all intensities; internal lustre between 3 and 4; vitreous; fracture small, imperfect, conchoidal, with a concealed foliated fracture, and fourfold cleavage; fragments sharp-edged; transparency 4 to 2; causes double refraction; scratches quartz with difficulty. Specific gravity from 2.600 to 2.7755.

The fossil here described is the occidental emerald, and appears from antique gems to have been known in the earlier ages, though at present it comes to us only from South America. Vauquelin found it to contain of silex 64.5, argil 16, glucine 13, oxide of chrome 3.25, lime 1.6, and water 2. The oriental emerald is a green corundum, of resplendent lustre, superior in hardness to every stone but the diamond, and of the specific gravity of 4.

EMERSION, in astronomy, is when any planet that is eclipsed begins to emerge or get out of the shadow of the eclipsing body. It is also used when a star, before hidden by the sun as being too near him, begins to re-appear or emerge out of his rays.

EMERSON (William), in biography, a late eminent mathematician, was born in June, 1701, at Hurworth, a village about three miles south of Darlington, on the borders of the county of Durham; at least it is certain that he resided here from his childhood. His father, Dudley Emerson, taught a school, and was tolerably proficient in mathematics; and without his books and instructions, perhaps, his son's genius, though eminently fitted for mathematical studies, might never have been unfolded. Beside his father's instructions, our author was assisted in the learned languages by a young clergyman, then curate of Hurworth, who was boarded at his father's house. In the early part of his life he attempted to teach a few scholars; but whether from his concise method, for he was not happy in explaining his ideas, or the warmth of his natural temper, he made no progress in his school; he therefore soon left it off, and, satisfied with a moderate competence left him by his parents, he devoted himself to a studious retirement, which he thus closely pursued, in the same place, through the course of a long life, being mostly very healthy till towards the latter part of his days, when he was much afflicted with the stone. About the close of the year 1781, being sensible of his approaching dissolution, he disposed of his whole mathematical library to a bookseller at York; and on May the 20th, 1782, his lingering and painful disorder put an end to his life, at his native village, being nearly 81 years of age.

Mr. Emerson, in his person, was rather short, but strong and well made, with an open countenance and ruddy complexion, being of a healthy and hardy disposition; he was very singular in his behaviour, dress, and conversation; his manner and appearance were that of a rude and rather boorish countryman; he was of very plain conversation, and seemingly rude, commonly mixing oaths in his sentences, though without any ill intention; he had strong good natural mental parts, and could discourse sensibly on any subject, but was always positive and impatient of contradiction; he spent his whole life in close study, and writing books, from the profits of which he redeemed his little patrimony from some original incumbrance; in his dress he was as singular as in every thing else; he possessed commonly but one suit of clothes at a time, and those very old in their appearance; he seldom used a waistcoat; and his coat he wore open before, except the lower button; and his shirt quite the reverse of one in common use, the hind side turned foremost, to cover his breast, and buttoned close at the collar behind; he wore a kind of rusty coloured wig, without a crooked hair in it, which probably had never been tortured with a comb from the time of its being made: a hat he would make to last him the best part of a lifetime, gradually lessening the flaps, bit by bit, as it lost its elasticity and hung down, till little or nothing but the crown remained.

He often walked up to London when he had any book to be published, revising sheet by sheet himself: trusting no eye but his own, was always a favourite maxim with him. In mechanical subjects, he

always tried the propositions practically, making all the different parts himself on a small scale; so that his house was filled with all kinds of mechanical instruments, together or disjointed. He would frequently stand up to his middle in water while fishing, a diversion he was remarkably fond of. He used to study incessantly for some time, and then for relaxation take a ramble to any pot ale house, where he could get any body to drink with, and talk to. The late Mr. Montague was very kind to Mr. Emerson, and often visited him, being pleased with his conversation, and used frequently to come to him in the fields where he was working, and accompany him home, but could never persuade him to get into a carriage; on these occasions he would sometimes exclaim, "Damn your whimwham! I had rather walk." He was a married man, and his wife used to spin on an old fashioned wheel of his own making, a drawing of which is given in his "Mechanics."

Mr. Emerson, from his strong, vigorous mind, and close application, had acquired deep knowledge of all the branches of mathematics and physics, upon all parts of which he wrote good treatises, though in a rough and unpolished stile and manner. He was not remarkable, however, for genius, or discoveries of his own, as his works hardly show any traces of original invention. He was well skilled in the science of music, the theory of sounds, and the various scales both ancient and modern; but he was a very poor performer, though he could make and repair some instruments, and sometimes went about the country tuning harpsichords.

The following is the list of Mr. Emerson's works, all of them printed in 8vo., excepting his "Mechanics" and his "Increments," in 4to. and his "Navigation" in 12mo. 1. The Doctrine of Fluxions. 2. The Projection of the Sphere, Orthographic, Stereographic, and Gnomonical. 3. The Elements of Trigonometry. 4. The Principles of Mechanics. 5. A Treatise of Navigation on the Sea. 6. A Treatise on Arithmetic. 7. A Treatise on Geometry. 8. A Treatise of Algebra in two books. 9. The Method of Increments. 10. Arithmetic of Infinities, and the Conic Sections, with other Curve Lines. 11. Elements of Optics and Perspective. 12. Astronomy. 13. Mechanics, with Centripetal and Centrifugal Forces. 14. Mechanical Principles of Geography, Navigation, and Dialling. 15. Commentary on the Principia, with the Defence of Newton. 16. Tracts. 17. Miscellanies.

EMERY, a stone of the ruby family, of which three kinds are usually distinguished in commerce; the Spanish, red, and common emery. The first sort is found in the gold mines of Peru, and, being judged a kind of marcasite of that rich metal, is prohibited to be exported. The red emery is found in copper mines, and the little there is of it in England comes from Sweden and Denmark. The common emery is taken out of iron mines, and almost the only sort used in England; it is of a brownish colour, bordering a little on red, exceedingly hard, and in consequence difficult to pulverize. The English are the only people who have the art of reducing common emery into powder, and thus send it to their neighbours. Of the powder, the most subtile and impalpable is the best; as to the stone, it should be chosen of a high colour, and as free of the rock as possible.

The consumption of emery is very considerable among the armourers, cutlers, lock-smiths, lapidaries, masons, and other mechanics; some of whom use it to polish and burnish iron and steel works; others to cut and scollop glass, marble, and precious stones.

EMETIC, a medicine which induces vomiting.

EMETIC *tartar*, the old name for tartrite of antimony.

EMOLLIENTS. See PHARMACY.

EMPETRUM, in botany, *heath*, a genus of the Dioecia Triandria class and order. Natural order of Ericæ, Jussieu. Essential character: male, calyx three-parted; corolla three-petalled; stamens long; female, calyx three-parted; corolla three-petalled; styles nine; berry nine-seeded. There are two species, *viz.* E. album, white-berried heath, and E. nigrum, black-berried heath, crow or crake berry. These are low shrubs, seldom propagated in gardens, unless for variety's sake. They are natives of wild mountains, where the soil is heathy and full of bogs.

EMPIS, in natural history, a genus of insects of the order Diptera. Generic character: mouth with an inflected sucker and proboscis; sucker with a single-valved sheath and three bristles; feelers short, filiform; antennæ setaceous. These minute insects live by sucking out the blood and juices of other animals. There are about thirty species. One of the

most common species in Europe is the E. livida, which is a brownish fly; the wings are transparent, with dark veins. They are observed in fields and gardens. E. borealis is of a more slender form than the common window fly, and of a blackish colour, with large, broad, oval wings, of a brown colour, and rufous legs varied with black.

EMPLASTRUM, in pharmacy, a composition for external use, generally spread upon leather, linen, or some other convenient thing, before it is applied. See Pharmacy. The following is a recipe for making the Ladies Court Plaster: "Dissolve five ounces of isinglass in a pint of water, and having ready a quantity of thin black sarsenet, stretched in a proper frame, apply the solution warm with a brush equally over the surface. This is to be repeated, after it is dry, two or three times." Some give it a coat of gum benzoin dissolved in alcohol; but this is injurious rather than beneficial.

EMPLEURUM, in botany, a genus of the Monoecia Tetrandria class and order. Natural order of Aggregatæ. Rutaceæ, Jussieu. Essential character: male, calyx four-cleft; corolla none: female, calyx four-cleft, inferior; corolla none; stigma cylindric, placed on the lateral toothlet of the germ; capsule opening on the side; seed one, arilled. There is but one species; *viz.* E. serrulatum, Cape empleurum. This is a shrub, with wand-like, even branches; leaves like those of a willow, alternate, subpetioled, linear-lanceolate, even above, beneath longitudinally wrinkled; peduncles few-flowered, lateral, much shorter than the leaves; flowers small, most of them male; capsules usually solitary, incurved with a beak of the same length.

EMULSION, a milky looking fluid, caused by an imperfect combination of oil with water, by means of mucilage, gluten, &c. All oily farinaceous seeds, as nuts, almonds, linseed, &c. form an emulsion by trituration with water; yolk of egg, which is a natural compound of oil and albumen, makes a similar emulsion.

ENAMELLING. Neri on glass, with the notes of Merret and Kunckel, afford a variety of good receipts for making enamels, though much still remains to be done in this art. The art is indeed retarded by the considerable advantages the enameller derives from the discovery of any colour uncommonly brilliant, clear, or hard. On this account the artist naturally endeavours to keep his process a secret, as the source of private gain. The principal ingredients of enamel colours are, however, well known.

There are two kinds of enamel; the opaque and the transparent. Transparent enamels are usually rendered opaque by adding putty, or the white oxide of tin, to them. The basis of all enamels is therefore a perfectly transparent and fusible glass. The oxide of tin renders this a beautiful white, the perfection of which is greater when a small quantity of manganese is likewise added. If the oxide of tin be not sufficient to destroy the transparency of the mixture, it produces a semi-opaque glass, resembling the opal.

Yellow enamel is formed by the addition of oxide of lead or antimony. Kunckel likewise affirms that a beautiful yellow may be obtained from silver.

Red enamel is formed by the oxide of gold, and also by that of iron. The former is the most beautiful, and stands the fire, which the latter does not.

Oxide of copper affords a green, manganese a violet, cobalt a blue, and iron a very fine black. A mixture of these enamels produces a great variety of intermediate colours, according to their nature and proportion. In this branch of the art the coloured enamels are sometimes mixed with each other, and sometimes the oxides are mixed before they are added to the vitreous bases.

The enameller who is provided with a set of good colours is very far from being in a situation to practise the art, unless he be skilled in the methods of applying them, and the nature of the grounds upon which they are to be laid. Many of the metals are too fusible to be enamelled, and most of them are corroded by the action of the fused glass. For this reason none of the metals are used but gold, silver, and copper. Platina has indeed been used; but of its effects and habitudes with enamel very little can be said, for want of a sufficient number of experiments.

The purest gold, of 24 carats, is calculated to produce the best effect with enamel. 1. Because it entirely preserves the metallic brilliancy, without undergoing any oxidation in the fire. 2. Being less fusible, it will admit of a more refractory, and consequently a harder and more beautiful enamel. It is not usual,

however, to enamel on finer gold than 22 carats; and the operation would be very defective, if a coarser kind than that of 18 carats were used. For in this case more alkali must be added to the enamel, to render it more fusible, and this addition would, at the same time, render it softer and less brilliant.

Rejecting all these exceptions, the following description may be taken, by way of example, of fixing a transparent blue enamel upon gold of 22 carats.

The artist begins his operation by breaking his enamel into small pieces in a steel mortar, and afterwards pulverizing it in a mortar of agate. He is careful to add water in this part of the process, which prevents the splinters of glass from flying about. There are no means of explaining the point at which the trituration ought to be given up, as this can be learned only by experience. Some enamels require to be very finely triturated; but others may be used in the form of a coarse powder. As soon as he apprehends that his enamel is sufficiently pounded, he washes it by agitation in very clear water, and pouring off the fluid as it becomes turbid. This process, which is made for carrying off dust and every other impurity from the enamel, is continued until the water comes off as clear as it was poured on.

The workman puts his enamel thus prepared into a white earthern or china saucer, with water poured on it to the depth of about one tenth of an inch. He afterwards takes up the enamel with an iron spatula as equally as posible. As the enamel here spoken of is transparent, it is usual to ornament the gold with rose work, or other kinds of work, calculated to produce a good effect through the enamel.

The thickness of this first layer depends entirely upon its colour: delicate colours in general require that it should have no great thickness.

The moist enamel, being thus placed, is dried, by applying a very clean half-worn linen cloth to it, which must be very carefully done, to avoid removing the enamel by the action of wiping.

In this state the piece is ready for the fire. If it be enamelled on both sides, it is placed upon a tile, or iron plate, hollowed out in such a manner, that the uncovered edges of the piece alone are in contact with the support. But if it be enamelled on one side only, it is simply laid upon the plate, or upon a tile. Two things, however, require to be attended to. 1. If the work be very small, or not capable of being enamelled on the opposite side, the iron plate must be perfectly flat, in order that the work may not bend when softened by heat. 2. If the work be of considerable size, it is always counter-enamelled, if possible; that is to say, an enamel is applied on the back surface, in order to counteract the effect which the other coating of glass might produce on the soft metal, when it came to contract by cooling.

The enameller's furnace is square, and built of bricks, bedded in an earth proper for the purpose. It may be considered as consisting of two parts, the lower part which receives a muffle resting on the floor of the furnace, and open on both sides.

The upper part of the furnace consists of a fire-place, rather larger and longer than the dimensions of the muffle. The fire-place contains the muffle, and must surround it on all sides, except at the bottom. The charcoal is put in at a door above the muffle, which is closed as soon as the fire is lighted. A chimney proceeds from the summit of the furnace, with a moderate aperture, which may be closed at the pleasure of the artist, by applying a cast iron plate to it. This furnace differs from that of the assayer, in the circumstance that it is supplied with air through the muffle itself: for if the draught were beneath the muffle, the heat would be too strong, and could not be stopped when requisite.

As soon as the fire is lighted, and the muffle has acquired the requisite degree of ignition, the charcoal is disposed towards the lower part of the muffle, in such a manner as that it shall not fall upon the work, which is then conveyed into the muffle, with the greatest care, upon the plate of iron or earthen-ware, which is taken out by long spring pincers. The work is placed as near as possible at the farther extremity of the muffle; and as soon as the artist perceives a commencement of fusion, he turns it round with great delicacy, in order that the fusion may be very uniform. And as soon as he perceives that the fusion has entirely taken place, he instantly removes it out of the furnace: for the fusion of gold happens so very near to that of the enamel, that the neglect of a few seconds might be attended with considerable loss.

When the work is cooled, a seond coat of enamel is applied in the same manner as the first, if necessary. This, and the

same cautious management of the fire, are to be repeated for every additional coat of enamel the nature of the work may demand.

As soon as the number of coatings are sufficient, it becomes necessary to give an even surface to the enamel, which, though polished by the fire, is nevertheless irregular. This is done with a fine grained Lancashire file and water. As the file wears smooth, sand is used. Much precaution and address are required in this part of the work, not only because it is easy to make the enamel separate in splinters from the metal, but likewise because the colour would not be uniform, if it were to be ground thinner at one part than at another.

The deep scratches of the file are in the next place taken out by rubbing the surface with a piece of deal wood and fine sand and water. A polish is then given by a second ignition. This polish, however, is frequently insufficient, and not as perfectly uniform as the delicacy of the work may require.

The substance used by the enamellers as a polishing material is known by the name of rotten-stone, which is prepared by pounding, washing, decanting off the turbid water, suffering the fine suspended particles to subside from this water, and lastly levigating it upon a glass plate.

The work is then cemented to a square piece of wood, with a mixture of resin and brickdust, and by this means fixed in a vice.

The first operation of polishing is made by rubbing the work with rotten-stone upon a small straight bar of pewter. Some delicacy is here required, to avoid scratching or producing flaws in the enamel by pressing too hard. In this way the piece is rendered perfectly even. But the last brilliant polish is given by a piece of deal wood and the same rotten-stone.

This is the general method of applying enamel; but some colours require more precaution in the management of the fire. Opaque colours require less management than the transparent. A variety of circumstances must be attended to in transparent colours; every colour requires gold of a particular fineness.

When different colours are intended to be placed beside one another, they are kept separate by a small edge or prominency, which is left in the gold for that purpose, and is polished along with the enamel.

The enamelling upon silver is effected nearly in the same manner as that of gold; but the changes sustained by the colours upon silver by the action of the fire are much more considerable than when gold is used.

Copper is not much used by enamellers, on account of the difficulty which attends the attempt to fix beautiful colours upon it. When this metal is used, the common practice is, to apply a coating of opaque white enamel, and upon this other colours which are more fusible than the white.

A good effect is produced in toys by leaving part of the gold bare. For this purpose its surface is cut into suitable compartments by the engraver. This, however, is an expensive method, and is for this reason occasionally imitated, by applying small and very thin pieces of gold upon the surface of the enamel, where they are fixed by the fire, and afterwards covered by a transparent vitreous coating.

A method of taking off the enamel from any toy, without injuring the metallic part, is often a desirable object. For this purpose a mixture of common salt, nitre, and alum in powder, is applied upon the enamel, and the piece is put into the furnace. As soon as the fusion has taken place, the piece is to be suddenly thrown into water, which causes the enamel to fly off either totally or in part. Any part which may still remain is to be removed by repeating the same operation a second time.

To coat vessels of iron or copper for culinary purposes with an enamel capable of defending the metal from the action of any solvent, and for enduring any heat, or transition from heat to cold, appears a desirable object; and many experiments have been made on the subject by Mr. Soen Rinman of the Royal Academy of Stockhlom.

The following compositions he found answer very well on copper. 1. The white semi-transparent fluor spar and sulphate of lime, in equal quantities, powdered, mixed, and calcinated in a white heat; then powdered, made into a thin paste with water, and applied a little warm to the vessel, also warmed. Then dried and heated gradually to a certain point, a very strong heat, greater than is generally obtained in an assaying furnace, is to be applied as quickly as possible. 2. Sixty parts of lime, one hundred of fluor spar, sixty of gypsum, twenty of quartz, and one of manganese, are calcinated, ground, and applied

in a similar manner. 3. Four parts of fluor spar, four of gypsum, and one of litharge, melted into a straw-coloured glass, ground and applied in the same way, required a much stronger heat. 4. Five parts of fluor spar, five of gypsum, two of minium, two of flint glass, half a part of borax, the same of oxide of tin, and one-twenty-fifth of a part of oxide of cobalt, melted together, made an enamel, which, when ground and applied as the others, fused with a less degree of heat. This, M. Rinman imagines, would have been acted upon in length of time by sulphuric acid. The oxide of cobalt was prepared by saturating a solution of cobalt in aqua-fortis with common salt, and evaporating to dryness.

As these would not do for iron, he tried the following: 1. minium, nine parts; flint glass, six; pure potash, two; nitre, two; borax, one; were ground together, put into a covered crucible, which they only half filled, and fused into glass. This poured out on a piece of marble, quenched in water, powdered and made into a thin paste, was laid on both sides of an iron vessel. After having been dried and heated gradually, the vessel was put under a muffle, well heated in an assaying furnace, and in half a minute the enamel melted. The vessel being then withdrawn, was found enamelled of a beautiful black colour, which appeared to be owing to a thin layer of oxided iron seen through the transparent glaze. 2. The same, with one hundredth part of oxide of cobalt prepared as above, covered the vessel more perfectly with a blue enamel. 3. The same, ground with potters' white lead, which consists of four parts of lead and one of tin, produced a very smooth grey enamel more firm and hard than the preceding. A small quantity of red oxide of iron gave it a fine dark red colour. 4. Flint glass, twelve parts; minium, eighteen; potash, four; nitre, four; borax, two; oxide of tin, three; oxide of cobalt, one eighth of a part; gave a smooth pearl coloured enamel, not brittle or subject to crack, and capable of enduring sudden changes of heat and cold, as well as the action of oils, alkalies, and weak acids: but it cannot resist the stronger vegetable acids, and still less the mineral.

These enamels were applied only on hammered iron, cast iron being too thick to be heated with sufficient quickness. But they have been applied to the thin cast vessels in England. It seems unnecessary to add, none of them will bear hard blows; and this is perhaps the reason why they have not been more used with us.

The application of enamel colours to glass or earthenware constitutes a peculiar branch of the art. M. Brougniart, of the porcelain manufactory at Sévres, has given a good account of them. (Nicholson's Journal, Vol. III. 4to.)

These bodies may be divided into three very distinct classes, from the nature of the substances that compose them, the effects produced on them by the colours, and the changes they undergo. These are, 1. enamel; soft porcelain, and all the glazes, enamels, or glasses, which contain lead in any considerable quantity. 2. Hard porcelain, or such as is glazed with feldspar. 3. Glass, in which there is no lead, such as the common window glass. The principles of composition of these colours, and the general phenomena they present on these three grounds or supporters, are regularly treated of.

Colours in enamel painting have been longest known. Enamel is a glass rendered opaque by oxide of tin, and very fusible by the oxide of lead. It is this last, which, in particular, gives it properties very different from those of the other excipients of metallic colours. Hence all the glasses and glazes which contain lead have the properties of enamel, and what we may assert of the one will apply to the other with very little difference.

Such are the white and transparent glazes of Dutch or Delf ware; and the glaze of the porcelain called soft ware.

This porcelain, the first made in France, particularly at Sévres, and indeed for a long time almost exclusively at that manufactory, has for its base vitreous frit, nearly opaque, capable of being acted upon by marle, and its glaze is very transparent glass, containing much lead.

The colours made use of are the same as those for enameling, consequently the changes these colours undergo in enamel must take place in this species of porcelain: the causes of the change being the same in both.

The colours for enamel and soft porcelain require less flux than the others, because the glass on which they are placed softens sufficiently to be penetrated by them.

This solvent may be either the mixture of glass of lead and pure silex, called rocaille, or this same glass mixed with that of borax.

Montamy says, that glass of lead ought not to be used in the flux or enamel; he employs borax alone. He then dilutes or makes up his colours in a volatile oil.

On the contrary, the painters of the manufactory at Sévres use only colours without borax, because they dilute them with gum, and borax does not dilute them well this way. M. Brougniart is convinced that both methods are equally good, and that Montamy is not justified in excluding the fluxes of lead, as they are employed without inconvenience every day, and even render the management of colours more easy.

It is remarked, that in the baking of these colours the glaze is softened so much as to be easily penetrated by them; and this is one great cause of the change they undergo. They become diluted by the mixture with the glaze, and the first fire changes a painting, apparently finished, into a very slight sketch.

The oxide of lead contained in the glaze is a more powerful cause of the great changes these colours undergo. Its destructive action is principally exercised on the reds of iron, and is very remarkable.

It has already been shewn that the two principal causes of the change, which colours on enamel and tender porcelain undergo, do not relate to the composition of these colours, but entirely to the nature of the glass on which theyare placed. The assertion that the colours of porcelain are subject to considerable change, relates to the colours of soft porcelain, a species of ware now almost totally abandoned.

Hence it follows, that the paintings of porcelain require to be several times retouched and burned, in order to possess the necessary strength. Though these paintings have always a certain softness, they are constantly more brilliant, and never subject to the inconvenience of scaling off.

Hard porcelain is the second species of ground or excipient for the metallic colours. It is known that the base of this porcelain is a very white argil, called kaolin, mixed with a siliceous and calcareous solvent, and the glaze is nothing but feldspar fused without an atom of lead.

This porcelain, which is that of Saxony, is of a much later date at Sévres than the soft or tender. The colours employed are of two kinds; the first, used for representing different objects, are baked with a very inferior fire to that required for baking the porcelain itself. They are very numerous and varied.

The others, which require to be fused at as great a heat as that for baking the porcelain, are laid on the general surface. They are much less numerous.

The colours for painting are made up very nearly of the same materials as those for tender porcelain; they only contain more flux. This flux is compossd of the glass of lead (called rocaille) and of borax. M. Brougniart asserts, that he has not met with any work that treats of the composition, use, and effects of these colours. In fact, it has no where been asserted, in print, that all these colours, except one, are unchangeable in fire; whereas it has been often asserted, in books, that paintings in enamel are subject to considerable change.

When the porcelain is put into the fire to bake the colours, the feldspar glaze dilates and opens in pores, but does not become soft. As the colours do not penetrate it, they are not subject to the changes they undergo on tender porcelain. It must, however, be observed, that they lose a little of their intensity by acquiring the transparence given them by the fusion.

When works of little importance are made, they need not be retouched; but this is necessary when a painting is to be highly finished. This retouching is not more distinguishable in paintings on porcelain, than in that of any other species of painting.

One of the great inconveniences of these colours is, that they scale or fly off when the fire is often applied.

This has been particularly remarked at Sévres, on account of the solidity and infusibility with which porcelain is there manufactured. But these qualities cause it to resist the alterations of heat and cold for a longer time, and give its ground a more brilliant colour. On the other hand, the porcelains of Paris being more vitreous, transparent, and of a bluish cast, generally crack, if boiling water is frequently poured into them.

In order to remedy this evil, without altering the quality of the body, Brougniart softens the glaze a little, by introducing more siliceous or calcareous flux, according to the nature of the feldspar. This method succeeded, and for twelve months then past the colours had past two and three times through the fires, without cracking, provided there were not too much flux, and they were not laid on too thick.

It has been remarked, that when soda and potash have been introduced, the colours scaled, so that they cannot be used as fluxes. These alkalies, being volatilized, abandon the colours which cannot adhere to the glaze by themselves.

It has been observed, that other colours are likewise prepared, which being laid upon the general surface, are fused by the same fire as bakes the porcelain. These colours are but few, because there are few metallic oxides that can support such a fire without being volatilized or discoloured. Their solvent is the feldspar. As they incorporate with the glaze they never crack, and are more brilliant.

The third receptacle of metallic vitrifiable colours is glass without lead.

The application of these colours constitutes the art of painting upon glass; an art much practised in former ages, but which was, till lately, supposed to be lost, because out of fashion. It, however, too immediately depends on the art of painting on enamel and porcelain to be lost. Descriptions of the processes may be found in different books.

A book, entitled "L'Origine de l'art de la Peinture sur Verre," published at Paris in the year 1693, and "Le Traité de l'art de la Verriere," by Neri and Kunckel, seem to be the first works containing complete descriptions of this art. Those published since, even the great work of Leviel, which constitutes part of "Les Arts et Metiers," of the French academy, and of the "Encyclopédie Methodique," are only compilations from the two former works.

It is somewhat remarkable, that if we follow the processes exactly as they are described in these works, as our author has done with some of them, the colours of which they pretend to give the receipt, would never be fabricated. They only serve to show an able practitioner the method, and leave it to him to correct or make additions. This was found to be the case by Citizen Meraud, who was engaged to prepare them for the manufactory of Sévres. He was obliged to make the colours for painting on glass rather from his own experience, than from the instructions in the work just mentioned.

The materials and fluxes which enter into the compositions of the colours for painting on glass are, in general, the same as those applied to porcelain. They vary only in their proportions; but a great number of the colours used for enamel and porcelain cannot be applied on glass; many of them, when seen by transmitted light, entirely change their aspect, and exhibit an obscure tint, which can be of no use when deprived of the white ground which throws them out. We shall point out these when we treat of the colours in particular. Those colours which can be used on this body sometimes change in the baking, and acquire a great transparency. They are generally beautiful only when placed between the eye and the light, and they answer the purpose intended in painting glass.

There is more difficulty in baking plates of coloured glass than is commonly thought. The bending of the piece and the alteration of the colours are to be avoided. All the treatises we have consulted recommend the use of gypsum. This method sometimes succeeded with Brougniart, but generally the glass became white, and cracked in all directions. It appears, that the glasses which are too alkaline, and which are far the most common in clear white glasses, are attacked by the hot sulphuric acid of the sulphate of lime. He was able with ease to bake much larger glasses than any before painted, by placing them on very smooth plates of earth or unglazed porcelain.

Concerning the several particular Colours.

After having collected the several phenomena which each class of vitrifiable colours offer, with regard to the bodies on which they are placed, we must shew the particular and most interesting phenomena, which every principal species of colours employed on tender porcelain, on glass, and in the fire that bakes the porcelain, present.

Concerning the Reds, Purples, and Violets, obtained from Gold.

The carmine-red is obtained from the purple precipitate of Cassius. It is mixed with about six parts of its flux, and this mixture is directly employed without being first fused. It is then of a dirty violet, but acquires the beautiful carmine by baking. It is however very delicate; a little too much heat or carbonated vapours easily spoil it; yet it is more beautiful when baked with charcoal than with wood.

This colour, and the purple, which dif-

fers little from it, as well as the shades which are obtained from their mixture with other colours, really change in all porcelains, and in the hands of all operators. But this is the only one which changes on hard porcelain. It may be replaced by a substitution of rose-colour from iron, which does not change; so that by excluding from the pallet the carmine made from gold, and substituting the rose-coloured oxide of iron here spoken of, we have a pallet composed of colours, none of which are subject to any remarkable change. The rose-coloured oxide of iron has been long known, but was not employed on enamel, because it is then subject to considerable change. Or, perhaps, when the painters on enamel became painters on porcelain, they continued to work according to their ancient method.

It might be supposed, that by previously reducing the colour flamed carmine, already mixed with its solvent into a vitreous matter, the last tint would be obtained; but the fire which must be used to melt this vitreous mass destroys the red colour. Besides, it is found, that, to obtain this colour in perfection, it is necessary to pass it through the fire as little as possible.

The carmine of tender porcelain is made of fulminating gold, gently decomposed, and muriate of silver; there is no tin in it, which proves it is not necessary, for the fabrication of a purple colour, that the oxide of this last metal and that of gold should be combined.

Violet is likewise obtained from the purple oxide of gold. This colour proceeds from having a greater quantity of lead in the flux, and it is nearly of the same tint, whether crude or baked.

These three colours totally disappear in the strong fire necessary to bake porcelain.

Carmine and purple afforded, upon glass, only tints of dirty violet. The violet, on the contrary, has a beautiful effect, but is subject to change to blue.

Concerning the Red, Rose, and Brown Colours, obtained from Iron.

These colours are made from red ozydated iron, prepared with nitric acid. The oxides are calcined still more by exposing them to the action of fire. If too much heated, they change to a brown.

Their flux is composed of borax and minium in small quantity.

These are the oxides which afford the rose and red colours, which may be substituted instead of the same colours made from oxide of gold. If properly applied on hard porcelain, they never change. Brougman made roses with these colours, and there was no difference between the flower, before and after baking, except the brilliancy which colours naturally receive from fusion.

The colours may either be previously fused or not, at pleasure.

In a violent fire, they either partly disappear, or produce a dull and brick-dust red colour, which is not at all agreeable.

Their composition is the same, either for tender porcelain or for glass. They do not change on the latter, but on the former they almost entirely disappear by the first fire; and they must be laid on very heavily, in order to have any part visible.

It is to the presence of lead in their glaze that this singular effect must be attributed. Brougman ascertained this by a very simple experiment. He placed this colour on window glass, and fired it very strongly, and it did not change. He then covered some parts of it with minium, and again exposed it to the fire. The colours totally disappeared in those places where the red oxide of lead had been applied. When this experiment was performed on a larger scale, in a closed vessel, a large quantity of oxygen gas was disengaged.

This observation seems clearly to prove the effect of oxydated lead as a discolourer of glass. We see that it does not operate, as has been supposed, by burning combustible impurities in the glass, but by dissolving, discolouring, and volatilizing the oxide of iron, which may affect its clearness.

Concerning the Yellows.

Yellows are colours which require much precaution in fabricating, on account of the lead they contain; which, sometimes, by approaching to the metallic state, produces black spots.

The yellows of hard and tender porcelain are the same. They are composed of oxide of lead, white oxide of antimony, and sand. Oxide of tin is sometimes added; and when it is required very lively, and resembling the colour of marigold, red oxide of iron is added, the very deep colour of which disappears during the previous fusion they undergo, on ac-

count of the lead contained in this yellow. When these colours are once made, they do not change: they disappear almost entirely in the porcelain fire-yellows.

These cannot be applied to glass; they are opaque and muddy. That employed by the ancient painters on glass is, on the contrary, beautifully transparent, very brilliant, and of a colour approaching gold. The processes they give indicate that it contains a mixture of silver; but when exactly followed they afford nothing satisfactory. Citizen Meraud succeeded in making it as beautiful as the ancient painters on glass, by employing muriate of silver, oxide of zinc, white clay, and the yellow oxide of iron. These colours are applied to glass simply ground, and without flux. The oxide of iron gives the yellow nearly the same tinge as it ought to have after the baking, and contributes, with the clay and oxide of zinc, to decompose the muriate of silver without disoxydating the silver itself. A powder remains after baking, which does not penetrate the glass, and may be easily cleared off.

This yellow when employed in greater quantities affords deeper shades, and produces a reddish colour.

Concerning the Blues.

These are known to be obtained from the oxide of cobalt; their preparation is known to every chemist. The superiority at Sévres, so justly reputed for the superiority of its blues, is owing merely to the care taken in its fabrication, and to the quality of the porcelain, which appears more proper to receive it, on account of the violent fire it can support.

Brougniart observed one fact respecting the oxide of cobalt, which is, perhaps, not known to every chemist. It is volatile in a violent heat; to this property must be attributed the bluish tint which the white (bordering upon blue) always receives. A white piece was purposely put in the same case next to a blue; the side of the white piece which was turned towards the blue became very bluish.

The blue of hard porcelain, prepared for what is called a blue ground by strong fire, is fused with feldspar; the solvent for tender porcelain is silex, potash, and lead; it is not volatilized like the preceding, because the fire is much inferior to that of the hard porcelain.

These colours, being previously fused, do not in the least change when applied.

The blues for glass are the same as for tender porcelain.

Concerning Greens.

The greens employed in painting are made with the green oxide of copper, or sometimes with a mixture of yellow and blue. They must be previously melted with their flux; without this precaution they would become black: but they do not change after the first fusion.

They must not be treated with a violent fire, or they would totally disappear. The green grounds by strong heat are made with the oxides of cobalt and nickel, but it is only a brownish green.

The bluish greens, named sky-blue, formerly a colour very much in esteem, can only be used on tender porcelain; they always scale off from hard porcelain, because there is potash in their composition. These greens cannot be used on glass, because they afford a dirty colour; it is necessary to put a yellow on one side, and a more or less pale blue on the other, in order to produce a green. This colour may likewise be fabricated, by mixing a blue with the yellow oxide of iron. Brougniart hoped to obtain a green from the oxide of chrome; and the experiments he made promised to be attended with success. The pure chromate of lead, fixed on porcelain by means of a strong fire, afforded him a very deep and very fixed blue, of considerable beauty.

Concerning Bistres and Brown Reds.

These are obtained by mixtures of different proportions of manganese, brown oxide of copper, and the oxide of iron, called umber. They are likewise previously fused in their solvents, so that they do not in the least change on tender porcelain, lead not having the same action on the oxide of manganese as it has on that of iron. This colour may be employed very well on glass.

The brown red, ground by strong heat, known by the name of *fonds caille*, are made in the same manner: feldspar is their flux. There is no titanium in their composition, though generally asserted in books. Titanium was not known at Sévres when Brougniart first came to that manufactory. He treated this singular metal in various ways, and never obtained any grounds but a slight obscure yellow, and very uncertain in its quality.

Concerning the Blacks.

Black colours are the most difficult to be obtained very beautiful. There is no metallic oxide, which, singly, affords a fine black. Manganese gives the best; iron, an opaque, dull, blistered black, which easily turns to red. The makers of colours have therefore combined several metallic oxides, which, singly, do not afford blacks, and they have obtained a very beautiful colour, but it is subject to scale and become dull.

The oxides are, those of manganese, the brown oxides of copper, and a little of that of cobalt. Grey is obtained by suppressing the quantity of copper and increasing the quantity of flux.

The Sévres manufactory is the only one which has as yet produced beautiful blacks with a strong fire. This is more owing to the quality of the biscuit, than to any peculiarity of process. It is by a mixture of blue with the oxides of manganese and iron that they make this very brilliant black.

The blacks for opaque glass are made the same as for painting, by giving different doses of solvent.

After the display of the principles of fabricating each principal colour, it is clear, that by mixing these colours all possible shades may be obtained: and also that care in the preparation, choice of materials, and just proportions of doses, must exhibit very sensible differences to the experienced eye of a painter. A knowledge of the composition of colours does not give the requisite care and neatness in making them up.

On recapitulating the facts here just stated, in order to present them in a general view, we see, first, that amongst the colours usually employed for hard porcelain, one only is susceptible of change, namely, the carmine: and this may be replaced by the reds of iron, and then no colour changes.

M. Brougniart presented to the Institute an unbaked head made in this manner, and a painting of two roses, the one baked, and the other in its first state. There was not any difference between them.

Secondly, That amongst the colours of soft porcelain and enamel, several change considerably, particularly the reds of iron and gold, with the yellows, greens, and browns. None have been substituted instead of them, this species of painting being almost abandoned.

Thirdly, That several of these colours change likewise upon the glass by becoming perfectly transparent, particularly the yellows and violets.

Fourthly, That neither an additional calcination, nor an additional fusion, as has been suspected, will prevent them from changing: for this method alters the colours that change, and does nothing to the rest. The change which several colours undergo on tender porcelain, and on glass, does not therefore relate to the nature of their composition, but rather to that of the body on which they are placed. Consequently, by suppressing the carmine of gold from the colours of hard porcelain, we shall have a series of unchangeable colours.

ENARGEA, in botany, a genus of the Hexandria Monogynia class and order. Essential character: calyx none; petals six, oblong, ovate, concave, acute, three outer, three inner, green spotted; berry three-celled, with four or five globular seeds. There is but one species. *viz.* E. marginata, a native of Terra Del Fuego.

ENCALYPTA, in botany, a genus of the Cryptogamia Musci class and order. Capsule cylindrical; fringe simple, of sixteen linear erect distinct teeth; veil campanulate, inflated, lax. There are six species.

ENCAUSTIC, the same with enamelling and enamel. See ENAMELLING.

ENCAUSTIC *painting*, a method of painting made use of by the ancients, in which wax was employed to give a gloss to their colours, and to preserve them from the injuries of the air.

ENCHASING, or CHASING, the art of enriching and beautifying gold, silver, and other metal work, by some design, or figures represented thereon, in low relievo. See RELIEVO and SCULPTURE.

Enchasing is practised only on hollow thin works, as watch-cases, cane-heads, tweezer-cases, or the like. It is performed by punching or driving out the metal, to form the figure from within side, so as to stand out prominent from the plane or surface of the metal. In order to this they provide a number of fine steel blocks, or puncheons, of divers sizes; and the design being drawn on the surface of the metal, they apply the inside upon the beads or tops of these blocks, directly under the lines or parts of the figures; then with a fine hammer, striking on the metal sustained by the block, the metal yields, and the block makes an indenture or cavity on the inside, corresponding to which there is a

prominence on the outside, which is to stand for that part of the figure.

Thus the workman proceeds to chase and finish all the parts, by successive application of the block and hammer to the several parts of the design. And it is wonderful to consider with what beauty and justness, by this simple piece of mechanism, the artist in this kind will represent foliages, grotesques, animals, histories, &c.

ENCHELIS, in natural history, a genus of the Vermes Infusoria. Worm invisible to the naked eye, very simple, cylindrical. There are fifteen species. An account of these may be found in Adams "On the Microscope."

ENCROACHMENT, in law, an unlawful gaining upon the rights or possessions of another. It is generally applied to the unlawful occupation of wastes and commons.

ENDEAVOUR, where one endeavours actually to commit felony, &c. he is punishable as for a misdemeanour; and an assault, with intent to rob, is punished by transportation. Statute 7 Geo. II. c. 21.

ENDECAGON, a plane geometrical figure of eleven sides and eleven angles. If each side of this figure be 1, its area will be $9.3656399 = \frac{11}{4}$ of the tangents of $73\frac{7}{11}$ degrees to the radius one.

ENDEMIC, or ENDEMICAL *diseases*, those to which the inhabitants of particular countries are subject more than others, on account of the air, water, situation, and manner of living.

ENDIVE, in botany, &c. broad-leaved succory. See CICHORIUM.

ENDOWMENT, in law, is the widow's portion; being a third part of all the freehold lands and tenements, of which her husband was seized at any time during the coverture. Of lands, not freehold, her portion varies, according to the custom in different places.

ENEMY, in law, an alien, or foreigner, who in a public capacity invades any country, and who cannot be punished as a traitor, but must be subjected to martial law. An alien residing in England, under the protection of the king's peace, may be dealt with as a traitor, because he owes a qualified allegiance.

ENFRANCHISEMENT, in law, the incorporating a person into any society or body politic; such as the enfranchisement of one made a citizen of London or other city, or burgess of any town corporate, because he is made partaker of its liberties or franchises.

ENGINE, in mechanics, is a compound machine made of one or more mechanical powers, as levers, pullies, screws, &c. in order to raise, cast, or sustain any weight, or produce any effect, which could not be easily effected otherwise.

Engines are extremely numerous; some used in war, as the battering ram, balista, waggons, chariots, &c. others in trade and manufactures, as cranes, mills, presses, &c.; others to measure time, as clocks, watches, &c.; and others for the illustration of some branch of science, as the orrery, cometarium, and the like.

In general, we may observe, concerning engines, that they consist of one, two, or more of the simple powers, variously combined together; that in most of them the axis in peritrochio, the lever, and the screw, are the constituent parts; that in all a certain power is applied to produce an effect of much greater moment; and that the greatest effect or perfection is when it is set to work with four-ninths of that charge which is equivalent to the power, or will but just keep the machine in equilibrio

In all machines the power will just sustain the weight, when they are in the inverse ratio of their distances from the centre of motion.

ENGINE, *fire*, by Rowntree. We have selected an engine by this maker to give a drawing and description, as it is greatly superior to the common engine with two force pumps. As that kind of engine has so often been described by various authors, and its principles so essily comprehended from the description of a force-pump, we judge it unnecessary to give any drawing of it.

The fire engine by Rowntree is a double force-pump, of a peculiar construction, similar in its action to the beer engine, (described under that article,) but as it is on a much larger scale, its constructions, are of course varied. Plate Rowntree's engine, fig. 1 and 2, are two elevations at right angles to each other, of the external part of the engine mounted on four wheels. Fig. 3 and 4, are two sections, perpendicular to each other, of the body of the engine or pump: fig. 5 and 6, are parts of the engine. The same letters are used as far as they apply in all the figures, A, A, A, A; fig. 3 and 4, is a cast-iron cylinder truly bored; it is ten inches diameter and fifteen long, it has a flanch at each end, whereon to screw two covers, with stuffing boxes, *a*, *a*, in their centres, through which the spindle, B, B, of the engine passes, and being tight

packed with hemp round the collar, makes a tight joint; the piston, D, is affixed to the spindle within the cylinder, and fits it tight all round by means of leathers, applied as described in the beer-engine; at E, fig. 4, a partition, called a saddle, is fixed in the cylinder, and fits against the back of the spindle tight by a leather.

We have now a cylinder divided by the saddle, E, and piston, into two parts, whose capacity can be increased and diminished by moving the piston, with proper passages and valves to bring and convey away the water: this will form a pump. These passages are cast in one piece with the cylinder: one, *d*, for bringing the water, is square, and extends about $\frac{1}{3}$ round the cylinder; it connects at bottom with a pipe, *e*; at its two upper ends opens into two large chambers, *f g*, extending near the whole length of the cylinder, and closed by covers, *h h*, screwed on: *i k*, are square openings (shown by dotted squares in fig. 3.) in the cylinder, communicating with the chambers: *f g*, *l m*, are two valves, closing their ends of the curved passage, *d*, and preventing any water returning down the passage, *d*: *n o*, are two passages from the top of the cylinder, to convey away the water; they come out in the top of the cylinder, which, together with the top of the chambers, *f*, *g*, form a large, flat surface, and are covered by two valves, *p q*, to retain the water which has passed through them. A chamber, K, is screwed over these valves: and has the air vessel *k*, fig. 1 and 2, screwed into its top; from each side of this chamber a pipe, *w w*, proceeds, to which a hose is screwed, as shown in fig. 1. Levers, *x x*, are fixed to the spindle at each end, as shown in fig. 1, and carry the handles, H H, by which men work the engine. When the piston moves, as shown by the arrow in fig. 4, it produces a vacuum in chamber, *f*, and that part of the cylinder contiguous to it; the water in the pipe, *e*, then opens the valve, *m*, and fills the cylinder. The same motion forces the water contained in the other part of the cylinder through the valve, *q*, into chamber, K, and thence to the hose through the pipe, *w*; the piston being turned the other way reverses the operation, with respect to the valves, though it continues the same in itself. The pipe, *e*, is screwed by a flanch to an upright pipe, P, fig. 5, connected with another square iron pipe, fastened along the bottom of the chest of the engine: a curved brass tube, G, comes from this pipe, through the end of the chest, and is cut into a screw, to fit on the suction hose, when it can be used; at other times a close cap is screwed on, and another brass cap at H, within the chest, is screwed upwards on its socket, to open several small holes made in it, and allow the water to enter into the pipe; in this case the engine chest must be kept full of water by buckets. The valves are made of brass, and turn upon hinges. The principal advantage of the engine is the facility with which it is cleaned from any sand, gravel, or other obstructions, which a fire-engine will always gather when at work.

The chambers, *f*, *g*, being so large, allow sufficient room to lodge a greater quantity of dirt than is likely to be accumulated in the use of the engine at any one fire; and if any of it accidently falls into the cylinder, it is gently lifted out again into the chambers by the piston, without being any obstruction to its motion: to clear the engine from the dirt, two circular plates, *r r*, five inches diameter, are unscrewed from the lids, *h h*, of the chambers *f g*, and when cleaned are screwed on again: these screw covers fit perfectly tight without leather, and can be taken out, the engine cleared, and enclosed again in a very short time, even when the engine is in use, if found necessary.

The two upper valves, *p q*, and chamber, K, can also be cleared with equal ease, by screwing out the air vessel, *k k*, fig. 1, which opens an aperture of five inches, and fits air-tight, without leather, when closed. The valves may be repaired through the same openings. The use of the air-vessel *k k*, fig. 1 and 2, is to equalize the jet from the engine during the short intermittance of motion at the return of the piston stroke: this it does by the elasticity of the compressed air within it, which forces the water out continually, though not supplied quite regularly from the engine.

The engine from which our drawing was taken was made for the Sun Fire Insurance Company, in London, and from some experiments made by their agent, Mr. Samuel Hubert, appears to answer every purpose.

Engine, *for raising water*. The frame of the machine is of cast iron, nearly in the form of the letter A; there are two of these frames, B B, (fig. 1, Plate Pump-Engine,) screwed together by means of five wrought iron pillars, *a a a a*; D is another smaller frame, to support the axis

of the fly wheel, connected with the other frame by three short pillars; E, is the fly wheel, turned by winches on the end of its axis; it has a pinion (13) of 13 leaves upon its axis, turning a wheel (48) of 48 teeth, on whose axis are two cranks *b*, *b*, opposite to each other, to work the pumps: *e e*, are the two crank rods, made each in two branches, and jointed at the lower end into two other rods, *f f*, which slide through holes made in the fixed bars, *g g*, fig. 2; the crank rods receive these bars between their two branches, and by this means, though the rods, *f f*, are confined by their guides to move truly vertical, the crank rods, *e e*, can partake of the irregular motion of the crank. The pump rods of the pumps are screwed to the rods, *f f*, by two nuts, and go down into the pumps, G H, supported from the iron frame by eight iron braces, *h h*. The pumps consist of two barrels, G H, with valves at the bottom, allowing water to enter them freely, but preventing its return; the buckets fixed to the pump rods fit the barrels truly, and have valves in them shutting downwards; I, is a chest bringing water to the valves in the bottom of the barrels; K, is another, communicating with the top of the barrels by two crooked passages, to carry away the water from them; the barrels are close at top, and the pump rods pass through close stuffing boxes, through which no water will leak by them. The action of the pump is the same as the common sucking pump: when the bucket is drawn up, the valve in it closes, and it forms a vacuum in the lower part of the barrel; this causes the water to ascend into it through the chest, I, to restore the equilibrium; at the same time it raises all the water which was above it through the chest, K; on the descent of the bucket the valve at the bottom of the barrel shuts, and prevents the escape of the water; the valve in the bucket opens, and the water passes through it, ready to be raised at the next stroke. The barrels in question are 3½ inches diameter, and 8 inches stroke. As the two cranks, *b*, *b*, are opposite each other, when one bucket is rising, the other is going down; by this means the power required to turn the machine by the handles is equalized, and also the quantity of water raised by the engine.

Engines for raising water, by the pressure and descent of a column inclosed in a pipe, have been lately erected in different parts of the country. The principle now adverted to was adopted in some machinery executed in France about 1731, and was likewise adopted in Cornwall more than forty years ago; but the pressure engine, of which we are about to give a particular decription, is the invention of Mr. R Trevithick, who probably was not aware that any thing at all similar had been attempted before. This engine, a section of which, on a scale of $\frac{1}{3}$d of an inch to a foot, is shewn in Plate Pressure-Engines; one was erected about eight years ago at the Druid copper mine, in the parish of Illogan, near Truro. A B, represents a pipe six inches in diameter, through which water descends from the head to the place of its delivery, to run off by an adit at S, through a fall of 34 fathoms in the whole; that is to say, in a close pipe down the slope of a hill 200 fathoms long, with 26 fathoms fall; then perpendicularly six fathoms, till it arrives at B, and thence through the engine from B to S two fathoms; at the turn B, the water enters into a chamber, C, the lower part of which terminates in two brass cylinders, four inches in diameter; in which two plugs or pistons of lead, D and E, are capable of moving up and down by their piston rods, which pass through a close packing above, and are attached to the extremities of a chain leading over and properly attached to the wheel Q, so that it cannot slip.

The leaden pieces, D and E, are cast in their places, and have no packing whatever. They move very easily; and if at any time they should become loose, they may be spread out by a few blows with a proper instrument, without taking them out of their place. On the side of the two brass cylinders, in which D and E move, there are square holes communicating towards G, with a horizontal trunk, or square pipe, four inches wide, and three inches deep. All the other pipes, G, G, and R, are six inches in diameter, except the principal cylinder wherein the piston, H, moves; and this cylinder is ten inches in diameter, and admits a nine foot stroke.

The piston rod works through a stuffing-box above, and is attached to M N, which is the pit rod, or a perpendicular piece divided into two, so as to allow its alternate motion up and down, and leave a space between, without touching the fixed apparatus, or great cylinder. The pit rod is prolonged down in the mine, where it is employed to work the pump; or, if the engine was applied to mill-work, or any other use, this rod would be the communication of the first mover. K L,

is a tumbler, or tumbling bob, capable of being moved on the gudgeons, V, from its present position to another, in which the weight L, shall hang over with the same inclination on the opposite side of the perpendicular, and consequently the end, K, will then be as much depressed as it is now elevated.

The pipe, R S, has its lower end immersed in a cistern, by which means it delivers its water without the posibility of the external air introducing itself; so that it constitutes a Torricellian column, or water barometer, and renders the whole column from A to S effectual, as we shall see in our view of the operation.

The operation. Let us suppose the lower bar, K V, of the tumbler to be horizontal, and the rod, P O, so situated, as that the plugs, or leaden pistons, D and E, shall lie opposite to each other, and stop the water ways, G and F. In this state of the engine, though each of these pistons is pressed by a force equivalent to more than a thousand pounds, they will remain motionless, because these actions being contrary to each other, they are constantly in equilibrio. The great piston, H, being at the bottom of its cylinder, the tumbler is to be thrown by hand into the position here delineated. Its action upon O P, and consequently upon the wheel, Q, draws up the plug E, and depresses D, so that the water way, F, becomes open from A B, and that of G to the pipe R: the water consequently descends from A to C, thence to F, until it acts above the piston F. This pressure forces down the piston, and if there be any water below the piston, it causes it to pass through G G G into R: during the fall of the piston, which carries the pit rod, M N, along with it, a sliding block of wood, I, (dotted) fixed to this rod, is brought into contact with the tail, K, of the tumbler, and lowers it to the horizontal position, beyond which it oversets by the acquired motion of the weight L.

The mere rising of the piston, if there was no additional motion in the tumbler, would only bring the two plugs, D and E, to the position of rest, namely, to close G and F, and then the engine would stop; but the fall of the tumbler carries the plug, D, upwards, quite clear of the hole, F, and the other plug, E, downwards, quite clear of the hole, G: these motions require no consumption of power, because the plugs are in equilibrio, as was just observed. In this new situation the column, A B, no longer communicates with F, but acts through G upon the lower part of the piston H, and raises it; while the contents of the great cylinder above that piston are driven out through F, and pass through the opening at D into R. It may be observed, that the column which acts against the piston is assisted by the pressure of the atmosphere, rendered active by the column of water hanging in R, to which that assisting pressure is equivalent, as has already been noticed. When the piston has ascended through a certain length, another slide or block upon the pit-rod (not seen) applies against the tail, K, of the tumbler, which it raises and again oversets, producing once more the position of the plugs D E, here delineated, and the consequent descent of the great piston H, as before described. The descent produced the former effect on the tumbler and plugs, and in this manner it is evident that the alternations will go on without limit, or until the manager shall think fit to place the tumbler and plugs, D E, in the positions of rest, namely, so as to stop the passages, F and G. The length of the stroke may be varied by altering the positions of the pieces, I, and the other lower down, which will shorten the stroke, the nearer they are together; as in that case they will sooner alternate upon the tail, K. As the sudden stoppage of the descent of the column, A B, at the instant when the two plugs were both in the water-way, might jar and shake the apparatus, those plugs are made half an inch shorter than the depth of the side holes, so that in that case the water can escape directly through both the small cylinders to R. This gives a moment of time for the generation of the contrary motion in the piston, and the water in G G G, and greatly deadens the concussion which might else be produced. See STEAM ENGINE.

Some former attempts to make pressure engines upon the principle of the steam-engine have failed; because water, not being elastic, could not be made to carry the piston onwards a little, so as completely to shut one set of valves and open another; in the present judicious construction, the tumbler performs the office of the expansive force of steam at the end of the stroke.

ENGINE *for driving piles,* used at building Westminster bridge, is constructed as follows: A, (Plate V. Miscel. fig. 3.) is the great shaft, on which are

the great wheel and drum : B, the great wheel with cogs, that turns a trundle head with a fly, to prevent the horse's falling when the ram is discharged; C, the drum on which the great rope is wound ; D the follower (with a roller at one corner) in which are contained the tongs, to take hold of the ram, and are fastened to the other end of the great rope, which passes over the pulley, near the upper end of the guides, between which the ram falls; E, the inclined planes, which serve to open the tongs, and discharge the ram; F, the spiral barrel that is fixed to the drum, on which is wound a rope with a counterpoise, to hinder the follower from accelerating, when it falls down to take up the ram ; G, the great bolt which locks the drum to the great wheel ; H, the small lever, which has a weight fixed at one end, passes through the great shaft below the great wheel, and always tends to push the great bolt upwards, and lock the drum to the great wheel; I, the forcing bar, which passes through the hollow axis of the great shaft, bears upon the small lever, and has near the upper end a catch, by which the crooked lever keeps it down ; K, the great lever, which presses down the forcing bar, and discharges the great bolt at the time the long end is lifted up by the follower; L, the crooked lever, one end of which has a roller, that is pressed upon by the great rope, the other end bears upon the catch of the forcing bar during the time the follower is descending; M, the spring that presses against the crooked lever, and discharges it from the catch of the forcing bar as soon as the great rope slackens, and gives liberty to the small lever to push up the bolt.

By the horse's going round, the great rope is wound about the drum, and the ram is drawn up, till the tongs come between the inclined planes, where they are opened, and the ram is discharged.

Immediately after the ram is discharged, the roller, which is at one end of the follower, takes hold of the rope that is fastened to the long end of the great lever, and lifts it up ; the other end presses down the forcing bar, unlocks the drum, and the follower comes down by its own weight.

As soon as the follower touches the ram, the great rope slackens, and the spring, M, discharges the crooked lever from the catch of the forcing bar, and gives liberty to the small lever to push up the great bolt, and to lock the drum to the great wheel, and the ram is drawn up again as before.

ENGINEER, in the military art, an able, expert man, who, by a perfect knowledge in mathematics, delineates upon paper, or marks upon the ground, all sort of forts, and other works proper for offence and defence. He should understand the art of fortification, so as to be able, not only to discover the defects of a place, but to find a remedy proper for them, as also how to make an attack upon, as well as to defend, the place. Engineers are extremely necessary for these purposes : wherefore it is requisite that, besides being ingenious, they should be brave in proportion. When at a siege the engineers have narrowly surveyed the place, they are to make their report to the general, by acquainting him which part they judge the weakest, and where approaches may be made with most success. Their business is also to delineate the lines of circumvallation and contravallation, taking all the advantages of the ground; to mark out the trenches, places of arms, batteries, and lodgments, taking care that none of their works be flanked or discovered from the place. After making a faithful report to the general of what is doing, the engineers are to demand a sufficient number of workmen and utensils, and whatever else is necessary.

ENGRAFTING or GRAFTING, in gardening. See the article GRAFTING.

ENGRAILED, or INGRAILED, in heraldry, a term derived from the French, hail; and signifying a thing the hail has fallen upon and broke off the edges, leaving them ragged, or with half rounds, or semicircles, struck out of their edges.

ENGRAVING. This term is at present confined to the art of excavating copper and wood, in lines, in so judicious a manner, as to produce imitations of paintings and drawings when painted on paper. It is certain that engraving for the production of prints was unknown long after the practice of painting in oil had arrived to great perfection, but good prints are common from plates engraved in the fifteenth century, many of which are landscapes, most laboriously, and even excellently, performed by the graver, although it is well known that the instrument just mentioned cannot freely express those serrated and serpentine lines, necessary for foliage and short

grass intermixed with plants, since so admirably delineated in etchings. A goldsmith of Florence, named Maso Finiguerra, is said to have discovered the art; but this assertion must undoubtedly merely apply to his obtaining impressions from lines engraved originally without the least idea of such a result; were we to examine the subject closely, it might be proved, that outlines have been cut in metals, representing figures, &c. from the most remote periods of antiquity, but being subject to decay, they have not reached our time, as the more durable granites have done, embellished with hieroglyphics cut in them in a manner which might be printed on paper. Arguing from these premises, it may be inferred, that the ancients understood the art of engraving in metal, though without conceiving that the copies of their productions might be multiplied by means of ink on soft white cloth, or similar materials. Albert Durer, born in 1470, and who died at Nuremberg, 1528, is said to have been the first person on record claiming the name of an engraver in the long list of celebrated artists; but certainly very excellent engraved brass figures, the lines filled with substances to show them more clearly, are now extant on tombs in some hundreds of churches in England, the dates of many of which are prior to the time of his birth. This fact will serve to prove that the *printing* of engraved plates was discovered between 1470 and 1528; indeed the perfection that engraving had reached in the latter century plainly demonstrates, that the use of the graver was by no means a modern discovery. The encouragement of the fine arts has ever been a distinguishing trait of the inhabitants of the continent of Europe; it is not wonderful, therefore, that engraving closely followed the footsteps of the parent arts, and flourished there in greater perfection than in England, where they have been in a state of miserable depression till within the last century, when literature was supposed to receive some aid from the graver; the booksellers, taking the hint, have encouraged the predilection of the public, which has operated as a stimulus to the artist, and the consequence is, that the graphic embellishments of British topographical and poetical works are equal, if not superior, to any in Europe.

Historical engravings for the port folio and furniture seemed at one period to advance rapidly towards perfection, to which the late Alderman Boydell greatly contributed; but the death of Strange, Hall, and Woollet, have been almost fatal to the hopes of the amateur, which rests, in a great measure, upon Heath, Sharp, Bromley, and a few others, as in this particular instance we do not include those eminent foreigners, who have or do at present reside in England. Whatever deficiencies we may discover in the prosecution of the arts in this country is, fortunately, not to be attributed to want of genius, or relaxation from study, in the artist; the chill of apathy in the rich, who view a wretched coloured aquatint with the same or more pleasure than the most laboured production of the graver, is the baleful cause of the languishing state of historical engraving. When persons capable of affording patronage are taught discrimination, future Woollets will fascinate the best judges of engraving.

We shall now proceed to explain the methods of executing different descriptions of engraving. The graver, an instrument of steel, is the primary object for engraving on copper; it is square for cutting of broad lines, and lozenge for the finest, and must be tempered to that exact state, which will prevent the point from breaking or wearing by its action on the metal; to obtain this state, is is customary to heat it when too hard on the end of a red hot poker, till it assumes a straw colour, and then cool it in oil; if held too long, it will become blue, soft, and useless, till the process of tempering the steel is renewed. As it is possible a graver may be of the proper degree of solidity, except in some inconsiderable part, it would be well to rub it on the oil stone till that is ascertained. The graver is inserted in a handle of hard wood, resembling a pear with a longitudinal slice cut off, which is to enable the artist to use it as flat on the plate as his fingers and thumb will permit. In order to prepare this instrument for cutting a clear smooth line, great care must be taken, in sharpening it, that the original general form should be preserved, by laying the sides flat upon the oil-stone, and rubbing them so as not to round them in the least, after which the graver is to be held sloping towards the person, and rubbed thus till the point is extremely sharp; besides these precautions, it will be necessary that the point should not be exactly in a right line with the lower part of the graver, but a little higher, that it may not press too deep into the copper. In rubbing the sides of the graver, the usual

manner has been to confine the right arm close to the side, placing the fore finger of the left hand on the upper side of the tool when on the stone. This instrument is used for finishing the imperfections discoverable in etchings, and exclusively in engraving writing.

The scraper is a long triangular piece of steel, tapering gradually from the handle to the point; the three edges produced by this form, being sharpened on the oil-stone, are used for scraping off the roughness occasioned by the graver, and erasing erroneous lines.

The burnisher is a third instrument of steel, hard, round, and highly polished, for rubbing out punctures or scratches in the copper. The oil stone has been already mentioned; to those may be added the needle or dry point for etching, and making those extremely fine lines which cannot be done with the graver.

Cushions made of soft leather, and filled with fine sand, hence called sandbags, are required for the support of the plate in engraving, which, from their circular surface, permit the copper to turn with ease, and facilitate the cutting of those true curves composing the shading of most subjects. The oil rubber and charcoal are necessary for polishing the plate.

Every thing depends upon the free use of the graver, therefore the utmost care must be taken to hold it properly, by preventing the interposition of the fingers between the graver and the plate, with the fore finger on the upper angle, which enables the artist to conduct it parallel with the substance engraved, thus preventing the point from entering deeply, and impeding the progress of the tool.

To engrave well requires good materials, though those are nearly confined to two, the graver, and the best copper; the latter should be free from flaws, small punctures, well hammered to close the pores, and polished to such a degree as to be free from the slightest scratches.

To trace the design intended for engraving accurately on the plate, it is usual to heat the latter sufficiently to melt white wax, with which it must be covered equally and thin, and suffered to cool; the drawing is then copied in outlines with a black-lead pencil on paper, which is laid with the pencilled side upon the wax, and the back rubbed gently with the burnisher, which will transfer the lead to the wax. The design must next be traced with an etching needle through the wax on the copper, when, on wiping it clean, it will exhibit all the outlines ready for the graver.

The table intended for engraving on should be perfectly steady, and the sandbags placed equally firm, in cutting of curved or undulating lines, the graver must be held still, or moved, to suit the turning of the plate with the left hand; but when straight lines are intended, the plate is to be held stationary, and the graver urged forward with more or less pressure, according to the thickness of the line. Great care is necessary to carry the hand with such steadiness and skill, as to prevent the end of the line from being stronger and deeper than the commencement; and sufficient space must be left between the lines, to enable the artist, to make those stronger, gradually, which require it. The roughness or burr occasioned by the graver must be removed by the scraper, the lines filled by the oil-rubber, and the surface of the copper cleansed, in order that the progress of the work may be ascertained.

If any accident should occur, by the slipping of the graver beyond the boundary required, or lines are found to be placed erroneously, they are to be effaced by the burnisher, which leaving deep indentings, those must be levelled by the scraper, rubbed with charcoal and water, and finally polished lightly with the burnisher.

As the uninterrupted light of the day causes a glare upon the surface of the copper, hurtful and dazzling to the eyes, it is customary to engrave beneath the shade of silk paper, stretched on a square frame, which is placed reclining towards the room, near the sill of a window.

Such are the directions and means to be employed in engraving historical subjects; indeed, the graver is equally necessary for the completion of imperfections in etching, to which must be added the use of the dry point in both, for making the faintest shades in the sky, architecture, drapery, water &c. &c.

Engraving of Mezzotintos differs entirely from the manner above described; this method of producing prints, which resemble drawings in Indian ink, is said by Evelyn, in his history of chalcography, to have been discovered by Prince Rupert, and was some years past a very favourite way of engraving portraits and historical subjects; of the former, the large heads by Fry are of superior excellence.

The tools required for this easy and rapid mode of proceeding are, the grounding-tool, the scraper, and the burnisher; the copperplate should be prepared as if intended for the graver, and laid flat upon a table, with a piece of flannel spread under it, to prevent the plate from slipping; the grounding-tool is then held perpendicularly on it, and rocked with moderate pressure backwards and forwards, till the teeth of the tool have equally and regularly marked the copper from side to side; the operation is afterwards repeated from end to end, and from each corner to the opposite; but it is necessary to observe, that the tool must never be permitted to cut twice in the same place; by this means the surface is converted into a rough chaos of intersections, which, if covered with ink and printed, would present a perfectly black impression upon the paper.

To transfer the design to be scraped, it is usual to rub the rough side of the plate with a rag dipped into the scrapings of black chalk, or to smoke it with burning wax taper, as in the process for etching; the back of the design is then covered with a mixture of powdered red chalk and flake white, and laid on the plate through which it is traced; particles of red, in the form of the outlines, are thus conveyed to the black chalk on the plate, which are to be secured there by the marks of a blunted point; the process must then be carried on with the scraper, by restoring the plate in the perfectly light parts of the intended print to a smooth surface, from which the gradations are preserved by scraping off more or less of the rough ground; but the burnisher is necessary to polish the extreme edges of drapery, &c., where the free touch of the brush in painting represents a brilliant spot of light. The deepest shades are sometimes etched and corroded by aqua fortis, and so blended with the mezzotinto ground added afterwards, that there is nothing offensive to the eye in the combination.

Many proofs are required to ascertain whether the scraping approaches the desired effect, which is done by touching the deficient parts with white or black chalk, on one of the proofs from the original drawing, and then endeavouring to make the plate similar by further scraping, or relaying the ground with a small tool made for this particular purpose, where too much of the roughness has been effaced.

Engraving on Steel is confined to the cutting of punches, for the conveyance of any form a certain depth into that or any other metal, seals, and dyes, for impressing the designs of coins, medals, &c. on gold, silver, or copper, &c. The punches are engraved from models in wax made in relievo, and, when completed, are tempered to that degree of solidity, which will bear the violent blows, without blunting the finest parts or breaking them, necessary to produce the matrix in the steel intended for striking of medals or coins, which must be heated to prevent such a disaster, and tempered again, for a similar reason to the preceding, after it is finished.

There are several tools used in finishing of dyes, which are, gravers, chissels, and flatters; and many little punches for making ornamental borders and mouldings to coins and medals; the latter are always in greater relief than the former, and consequently more difficult to execute in perfection.

Engraving on precious Stones is accomplished with the diamond or emery. The diamond possesses the peculiar property of resisting every body in nature, and, though the hardest of all stones, it may be cut by a part of itself, and polished by its own particles. In order to render this splendid substance fit to perform the operations of the tool, two rough diamonds are cemented fast to the ends of the same number of sticks, and rubbed together till the form is obtained for which they are intended; the powder thus produced is preserved, and used for polishing them in a kind of mill furnished with a wheel of iron; the diamond is then secured in a brazen dish, and the dust mixed with olive oil applied, the wheel is set in motion, and the friction occasions the polished surface so necessary to give their lustre due effect. Other stones, as rubies, topazes, and sapphires, are cut into various angles on a wheel of copper, and the material for polishing those is tripoli diluted with water.

A leaden wheel, covered with emery mixed with water, is preferred for the cutting of emeralds, amethysts, hyacinths, agates, granites, &c. &c. and they are polished on a pewter wheel with tripoli; opal, lapis lazuli, &c. are polished on a wheel made of wood.

Contrary to the method used by persons who turn metals, in which the substance to be wrought is fixed in the lathe, turned by it, and the tool held to the sub-

stance, the engraver of the crystal, lapis lazuli, &c. fixes his tools in the lathe, and holds the precious stone to them, thus forming vases, or any other shape, by interposing diamond dust mixed with oil, or emery and water, between the tool and the substance, as often as it is dispersed by the rotary motion of the former.

The engraving of armorial bearings, single figures, devices, &c. on any of the above stones, after they are polished, is performed through the means of a small iron wheel, the ends of the axis of which are received within two pieces of iron, in a perpendicular position, that may be closed, or otherwise, as the operation requires; the tools are fixed to one end of the axis, and screwed firm; the stone to be engraved is then held to the tool, the wheel set in motion by the foot, and the figure gradually formed. The materials of which the tools are made is generally iron, and sometimes brass; they are flat, like chissels, gouges, ferules, and others have circular heads. After the work is finished, the polishing is done with hair brushes, fixed on wheels and tripoli.

Engraving in wood, has been practised for several centuries, and originally with tolerable success; it languished for great part of the 18th century, but revived towards the close, and is still practised in a manner which reflects credit on the ingenuity of the age. Bewick will long be remembered by his works in this style of engraving, and his imitators have been numerous and successful. As it is entirely different from engraving on copper, the artist already acquainted with that mode would find himself at a loss how to proceed on wood, as the lines, instead of being cut into the substance, are raised, like the letters of printing types, and printed in the same manner.

The wood used for this purpose is box, which is preferred for the hardness and closeness of its texture; the surface must be planed smooth, and the design drawn on it with a black lead pencil; the graver is then used, the finer excavations from which are intended for white interstices between the black lines produced by leaving the box untouched, and the greatest lights are made by cutting away the wood entirely, of the intended form, length and breadth; but the deepest shades require no engraving. Much of the beauty of this kind of engraving depends upon the printing, nor is it every artist who can excel in it, as expedition and freedom are not to be attained: in short, the best wooden cuts are evidently the products rather of perseverance and ingenuity than easy confidence in ability, observable in every line of fine etchings. There are some who succeed to admiration in representing foliage and plants, but unfortunately a few months practice will enable a pupil to etch them on copper with greater truth: drapery and architecture may be well done in wood, but the faces and limbs of figures never look well.

Such are the different descriptions of engraving which do not require the aid of aqua fortis; of those made by the intervention of that liquid, the principal is *Etching*. He that would excel in this branch of the arts must be thoroughly acquainted with drawing; otherwise his works will appear tasteless indeed. The ground used in etching is a combination of asphaltum, gum mastic, and virgin wax, mixed in such proportions as will prevent the asphaltum from breaking the composition, when under the aqua fortis, or the wax from making it so soft as to close the lines when cut through it by the needle. As every thing depends upon the stability of the ground, it should be purchased of those persons who are most celebrated for making it; or if the person wishing to use it prefers doing it himself, let him remember, that he must keep every particle of grease or oil far from him and his materials, and that, without the greatest care, the inflammability of the asphaltum will ruin his operations in melting them. The proportions of the ingredients should be obtained by experiment.

After being prepared in the above manner, the ground is tied in a piece of lustring for use, and another piece of the same kind of silk must be made into a dabber by tying a quantity of cotton in it. The copper-plate, hammered to a considerable degree of hardness, polished as if intended for the graver, and perfectly cleansed with whiting, is then secured at one corner by a hand vice, heated over a charcoal fire, and the silk containing the ground rubbed over it, till every part is covered by the melted composition; but before it cools the silk dabber must be applied in all directions, till the surface of the plate is thinly and equally varnished. After this part of the process is completed, several lengths of wax taper, twisted together, are to be lighted, the plate rais-

ed by the vice in the left hand, and the right, holding the burning taper, is to be moved gently backwards and forwards under the ground, carefully avoiding touching it with the wick, yet causing the flame to spread over the surface, which will render it perfectly black, smooth, and shining, in a short time ; this is to be ascertained by turning the plate : If the copper appears through the ground, the taper must be applied again immediately ; but if it is held too long beneath the plate, the ground will become opaque, and break when the aqua fortis is used.

The next object is, to transfer the design to the ground, which may be done by drawing it on thin white paper with a black-lead pencil, and having it passed through the copper-plate printer's rolling press, who will accomplish it by laying the plate carefully on the board of his press, the pencilled paper slightly damped on it, and turning the press, the lead will be conveyed firmly to the ground, which will appear in perfect outlines on removing the paper. Another method is, to draw the design reversed from the original; rub the back with powdered white chalk, and laying it on the ground, trace the lines through with a blunt point: this operation requires much precaution, or the point will cut the ground; besides, if the paper is not securely fastened with wax at the corners, it may slip, and either interrupt the true continuation of the lines, or scratch the ground.

In working with the etching needle nothing more is required than to keep it upright, that the lines made by it through the ground may not slope, and thus make the aqua fortis corrode improperly ; but it should be particularly observed, that the point, though taper, must be so rounded as to be free from a possibility of its tearing the surface of the copper, which would prevent the progress of the point, and ruin the plate when bitten ; the necessary polish of the point may be accomplished by rubbing it on the sole of a shoe. The young artist must now be left to his own exertions, as directions for etching beyond those already given are useless, and he will acquire more knowledge and freedom from copying good prints in one week than a quarto volume of observations would afford. It seems almost needless to add, that every line must be kept distinct, at all events, throughout the plate, and that the most distant should be closer and more regular than those in the fore-ground, as the greater the depth of shade the broader and deeper must the lines be made.

When the etching of the plate is completely finished, the edges of it must be surrounded by a high border of wax, so well secured that water will not penetrate between the plate and it. The best spirits of nitre fortis must then be diluted with water, in the proportion of one part of the former to four of the latter, which will be found to answer the first operations, if the weather is fine and the atmosphere free from moisture ; but if the contrary is the case, the spirits of nitre must be increased in proportion to the humidity of the air ; this, when poured on the plate, cannot be too attentively observed, in order to remove the bubbles of fixed air with a feather, and to ascertain the time for stopping out the lightest parts; for it must be remembered, the whole secret of biting or corroding any subject consists in the judicious manner in which the depth and breadth of the lines are varied, as by proper management they may be left scarcely perceptible, or increased very considerably. The composition used for the above purpose is turpentine varnish mixed with lamp-black, and diluted so as to be used freely with a camel's hair pencil; this, applied to the parts of the plate sufficiently corroded, will effectually prevent the aqua fortis from touching it again, and the remainder proceeds as if no such application had taken place : it will be necessary to strengthen the water as the work becomes nearer completion, but cautiously, lest the ground should be broken ; and every time the aqua fortis is removed, the plate must be washed with clean water, and gradually dried, otherwise the varnish cannot be used, and the lines would be clogged with the decomposed metal. For taking the ground from the plate it is usual to cover the surface with olive oil, and heating it, wipe the plate with a soft piece of old linen and spirits of turpentine, will effectually remove all remaining dirt.

Re-biting, is the art of strengthening those lines of an etching, in a plate from which the original ground has been cleansed. This is done by applying the ground as at first directed, but with great care, that the melted composition does not fill, or even partially fill the lines, to prevent which the cotton wrapt in silk, called the dabber, should be used exclusively, by taking a small quantity of melted ground on it, and gently touching the parts be-

tween the lines, till they are equally and completely covered; if the plate is considerably heated, the ground will spread with more facility over the various interrupted surfaces. Carelessness or inattention will instantly ruin this process, and the whole of the plate: a border of wax must surround the parts to be re-bitten, and a channel made to carry off the aqua fortis without injuring those already completed. Supposing the operations of etching and biting the plate entirely finished, nothing more remains than to examine it attentively, and improve it with the graver and dry point.

Stipling, or engraving in the dotted manner, was in a great measure introduced by Bartolozzi, whose works in this way are astonishingly numerous, exclusive of those to which his name is affixed, and not the products of himself. Some pastoral scenes, with figures, when printed in colours, have a pleasing effect; and small portraits stipled will bear examination; but historical subjects, which have great breadth of shade, appear to no advantage engraved in this manner. Stipling is performed by etching the plate with dots, and biting it, laying the shades with a tool for the purpose, using the graver and the dry point, and scraping off the roughness thus occasioned.

Engraving in Aquatinta. The print from an aquatinted plate resembles a neatly finished drawing in Indian ink; this effect is produced by corroding the plate between the particles of a material entirely different from the etching ground. The first step in this process is, to prepare a plate exactly in the way already described, and etch the outlines of the subject to be aquatinted, which are to be slightly bitten, and the plate thoroughly cleansed. The substance used to form the grains of the subject (which may be common resin, burgundy-pitch, asphaltum, gum-mastich, or gum-copal, either separate or mixed) should be reduced to a fine powder and sifted, put into a piece of muslin, and holding it high above the plate, it must be struck against any substance held in the left hand, till the shower of dust thus produced has covered the plate equally throughout; preserving it carefully in this situation, the plate is to be heated sufficiently to melt the powder, which will make the grains assume a circular form, and contract, leaving, when cold, a beautiful surface fit for the aqua fortis. Common resin is generally preferred for this part of the operation, but gum-copal is less liable to be broken loose from the plate during the process of biting.

The drawing to be copied must serve as the future basis of proceeding, which is to be imitated in the following manner: the perfectly white parts of the intended print are to be covered on the plate with the varnish mentioned in etching, by the use of a camel's-hair pencil, a border of wax must then be raised, and the aqua fortis, diluted, poured on; the same method is afterwards practised in the stopping out before recommended, except that the depth of the corroding cannot be so great as in the line manner.

In order to obviate any difficulties which occur in procuring sufficient depths of shade, a method has been invented, that enables the artist to produce an effect almost equal to the decisive touches of a brush filled with colour in drawing, which is the use of a liquid made with water, treacle, or sugar, and fine washed whiting, exactly of the consistence of Indian ink, and laid on the granulated surface with a pencil, in the same free manner adopted on paper; after the above composition is thoroughly dry, the whole plate must be covered with a thin, weak, varnish of mastich, turpentine, or asphaltum, and, when dried a second time, the aqua fortis is to be applied, which immediately breaking the varnish and whiting, will corrode the plate precisely in the marks of the pencil. The border of wax may be removed by heating the plate gently, and the ground varnish, &c. by oil of turpentine; a little fine whiting and a clean rag will then render the plate fit for the printer.

As the manner of procuring the grain by heating the powdered substance scattered over the plate is liable to objections, on account of the difficulty of making the particles assume the desired coarseness, or the reverse, and the engraving so produced rapidly wearing out in the printing, another has been contrived, far more certain and satisfactory. In this mode, common resin, mastich, or Burgundy pitch, is dissolved in highly rectified spirits of wine of the best quality, each of which produces different descriptions of grains; but these substances may be mixed in such proportions as the artist prefers, and he must recollect that the resin makes the coarsest; to satisfy himself in this prrticular, the grain of every proportion should be tried on useless pieces of copper. Having a solution to his mind, it must remain undisturbed till every impure particle has

subsided. The plate, polished and cleansed with whiting, is then placed to receive the liquid, which being poured on it, is held slanting till the most fluid parts have run off; it is afterwards laid to dry, in the progress of which the resin granulates, and adheres firmly to the surface. The greatest precaution must be used in going through this process, as the interposition of dust, grease, hairs, or fibres of linen, will cause total derangement; and even then it is subject to most vexatious uncertainty, often compelling the experienced artist to renew it to obtain a good grain; in short, the weather and untoward accidents frequently ruin his labours, though guarded against by every method his invention suggests. There is one advantage attending the pouring the liquid off, which is, that the heaviest particles of the resin will float to the lower side, and consequeutly leave a coarser grain there than above, much better suited to the deep shades of a landscape than if the granulations had been equally fine; in large subjects the grain is sometimes laid coarse purposely in the parts requiring it.

Although a fine grain has a very pleasing effect, and will bear close examination, it has several disadvantages; for this reason a medium description of granulation is preferable, which, admitting the aqua fortis freely to the copper, it bites deeper, and is less apt by acting laterally to force off the resin; besides, the plate will of course afford a greater number of impressions.

Some hints have been given already for biting the plate; but however useful those may be found in particular instances, there are others which can only be extracted from close application and experiment, and those are often varied in their results: as an illustration, we may suppose an artist provided with several pieces of copper granulated, and trying each successively by his watch with spirits of nitre diluted to the state of the air at the commencement of his operations, how many minutes are necessary to produce one tint, how many for a second, &c. granting him two hours for his experiment; during this interval a violent shower of rain may occur, which will immediately affect the acid, by weakening its properties in the same proportion as salt is observed to be dissolved by a humid atmosphere: thus it appears, a result obtained on a clear dry day will not suit a rainy one, and *vice versa.*

In opposition to this discouraging uncertainty, and in opposition to the judgment and preference of all true connoisseurs, aquatinted prints seem to increase in value in the estimation of many persons, who forget that national taste should be improved by works of superior execution, and not vitiated by being constantly familiarized to those produced by means which set genius at defiance.

ENNEAGON, in geometry, a polygon with nine sides. If each side be 1, the area will be 6, 18, &c.

ENNEANDRIA, the name of the ninth class in Linnæus's sexual system, consisting of plants which have hermaphrodite flowers, with nine stamina or male organs. The orders, or secondary divisions in this class, are three, being founded on the number of the styles, seed buds, or female organs. Laurus, tinus, and cassytha, have one style; rhubarb, (rheum,) has a triple stigma or summit, but scarce any style; flowering rush has six styles. The genera just enumerated are all that belong to the class Enneandria. The first genus, laurus, is very extensive; comprehending the bay-tree, cinnamon tree, camphor tree, benjamin tree, sassafras tree, and the avocado or avogato pear.

ENS *martis*, an old name given by chemists to sal ammoniac sublimed with iron filings, and therefore consisting of muriate of ammonia mixed with a little muriate of iron.

Ens *veneris*, a similar preparation, in which copper filings are substituted for those of iron.

ENSATÆ, (from *enses*, a sword,) the name of the sixth order in Linnæus's Fragments of a Natural Method, consisting of plants with sword-shaped leaves.

ENSIFORM, in general, something resembling a sword, *ensis*: thus we find mention of ensiform leaves, ensiform cartilage, &c.

ENSIGN, in the military art, a banner under which the soldiers are ranged, according to the different companies or places they belong to. The European ensigns are pieces of taffety with various figures, arms, and devices, painted on them in different colours: the Turkish ensigns are horses' tails.

Ensign is also the officer that carries the colours, being the lowest commissioned officer in a company of foot, subordinate to the captain and lieutenant. It is a very honourable and proper post for a young gentleman on his first coming into the army; he is to carry the colours,

both in assault, day of battle, &c. and should not quit them but with his life; he is always to carry them himself on his left shoulder, only on a march he may have them carried by a soldier. If the ensign is killed, then the captain is to carry the colours in his stead.

ENTABLATURE, in architecture, is that part of an order which rests on the capital of a column, and comprehends the architrave, frieze and cornice.

ENTAIL, in law, signifies fee-tail, or fee intailed. See Estate.

ENTIERTIE denotes the whole, in contradistinction to moiety, which denotes the half; and a bond, damages, &c. are said to be entire, when they cannot be apportioned.

ENTIRE *tenancy*, signifies a sole possession in one man.

ENTOMOLOGY is that branch of natural history that treats of insects. The study of insects has sometimes been ridiculed as unworthy the attention of men of science; for this, however, there is no just reason; though inferior in point of magnitude, yet they surpass, in variety of structure and singularity of appearance, all the larger branches of the animal world. No one can examine with an attentive eye the subjects of this branch of science without surprise; the great variety of forms, the nice adaptation of their parts to the situation in which each happens to be placed, may excite the amazement of the curious and intelligent mind The same power and wisdom which are manifested in the order, harmony, and beauty of the heavenly bodies, are equally shown in the formation of the minutest insect, each has received that mechanism of body, those peculiar instincts, and is made to undergo those different changes, which fit it for its destined situation, and enable it to perform its proper functions. The utility of many insects, either in their living or dead state, as the bee, the crab, the silk worm, cochineal insect, (see Apis, Coccus, &c.) renders them interesting and important; besides, tho' diminutive in point of size, they are, in regard to numbers, unquestionably the most distinguished of the works of nature; they are to be found in every situation, in water, in air, and in the bowels of the earth; they live in wood, upon animals, decayed vegetables, and all kinds of flesh, and in every state of its existence down to the most putrid.

The general characters by which insects are distinguished are the following: they are furnished with six or more feet; the muscles are affixed to the internal surface of the skin, which is a substance more or less strong, and sometimes very hard and horny; they do not breathe like larger animals, by lungs or gills situated in the upper part of the body; but by a sort of spiracles distributed in a series or row on each side the whole length of the abdomen; these are supposed to communicate with a continued chain, as it were, of lungs, or something analogous to them, distributed throughout the whole length of the body; the head is furnished with a pair of what are termed antennæ, or horns, which are extremely different in different tribes, and which by their structure, &c. form a leading character in the institution of the genera into which insects are divided.

Writers on natural history formerly included snails, worms, and the smaller animals, or animalcules, in general, among insects: these are now more properly placed among the tribe vermes, or worm-like animals Late writers have extended this still further, and have very properly excluded almost the entire Linnæan order of Aptera. forming of it a distinct class, under the name of Crustacea. Insects have also been denominated bloodless animals, which modern discoveries have shewn to be contrary to fact: their blood is generally a colourless sanies. Some of them, as the cimex lectularius, have been frequently used, with the microscope, to exhibit in a striking manner the circulation of the blood. In this insect, with a good glass, the vibrations and contractions of the arteries may be distinctly observed.

Most insects are oviparous; of course, the first state in which insects appear is that of an ovum or egg. This relates to the generality of insects, for there are some examples of viviparous insects, as in the genera Aphis, Musca, &c. From the egg is hatched the insect in its second or caterpillar state; this second state has been usually known by the name of eruca, but Linnæus has changed it to that of Larva, which see; considering it as a sort of masked form, or disguise, of the insect in its complete state. The larvæ of insects differ very much from each other, according to the several tribes to which they belong: those of the butterfly and moth tribe (phalæna) are generally known by the name of caterpillars; those of the beetle (scarabæus,) except such as inhabit the water, are of a thick, clumsy form. The larvæ of the locust, or grass-hopper, (gryllus,) do not differ very

much in appearance from the complete insect, except being without wings. The larvæ of flies, bees, (musca, apis,) &c. are generally known by the name of maggots, and are of thick short form. Those of water beetles (dytiscus) are of highly singular forms, and differ, perhaps, more from that of the complete insect than any others, except those of the butterfly tribe. Some insects undergo no change of shape, but are hatched from the egg complete in all their parts, and they undergo no farther alteration than that of casting their skin from time to time, till they acquire the complete resemblance of the parent animal. In the larvæ state most insects are peculiarly voracious, as in many of the common caterpillars. In their perfect state some insects, as butterflies, are satisfied with the lightest nutriment, while others devour animal and vegetable substances with a considerable degree of avidity. When the larva is about to change into the crysalis or pupa state, it ceases to feed, and having placed itself in some quiet situation, lies still for several hours, and then, by a sort of effort, it divests itself of its external skin, and immediately appears in the different form of a chrysalis or pupa; in this state, likewise, the insects of different genera differ almost as much as the larva. In most of the beetle tribe it is furnished with short legs, capable of some degree of motion, though very rarely exerted. In the butterfly tribe it is destitute of legs; but in the locust tribe it differs very little from the perfect insect, except in not having the wings complete. In most of the fly tribe it is perfectly oval, without any apparent motion or distinction of parts. The pupa of the bee is not so shapeless as that of flies, exhibiting the faint appearance of limbs. Those of the dragon-fly (libellula) differ most widely from the appearance of the complete insect; from the pupa emerges the insect in its ultimate form, from which it never changes, nor receives any farther increase of growth.

Different naturalists have attempted to arrange insects into families and genera, particularly the celebrated Linnæus, whose arrangement may be thus explained. He has formed them into seven families or orders, composing his sixth class of animals, Insecta: he defines an insect, a small animal, breathing through pores on its sides, furnished with moveable antennæ and many feet, covered with either a hard crust or a hairy skin. As introductory to the distinguishing marks of the orders and genera, it will be necessary to enumerate and explain the terms given to the different parts, and the most remarkable of the epithets applied to them by entomologists. The body is divided into head, trunk, abdomen, and extremities.

1. Caput, the head, is in insects, as well as in the vertebral animals, the principal repository of the senses, and contains that most important organ, the brain: externally it is furnished with eyes; stemmata; antennæ; clypeus; vertex; mouth; front; gula.

Eyes, are situated on each side of the head, and differ much in form and colour in the different insects, and may be considered amongst the most surprising of nature's works; they are not, as might be at first supposed, mere hemispherical bodies of plane and simple surfaces, but examination proves them to be composed of an immense assemblage of highly wrought hexagonal fascets, each furnished with its proper optic nerve, retina, &c. complete for vision: the number of these fascets differs in different species; in the eye of the common fly 8,000 have been counted, and in that of the libellula or dragon fly about 12,000.

Stemmata are hemispherical bodies placed upon the vertex, and are supposed to perform the office of eyes. The antennæ are two articulated moveable processes, placed on the head; they are either, 1. Setacea, setaceous, *i. e.* like a bristle, when they taper gradually from their base to their point. 2. Clavatæ, clavated, *i. e.* club-shaped, when they grow gradually thicker from their base to their point. 3. Filiformes, filiform, *i. e.* thread-shaped, when they are of an equal thickness throughout the whole of their length. 4. Moniliformes, moniliform, *i. e.* of the form of a necklace, when they are of an equal thickness throughout, but formed of a series of knobs, resembling a string of beads. 5. Capitatæ, capitate, when they grow thicker towards the point, and terminate in a knob or head. 6. Fissiles, fissile, *i. e.* cleft, when they are capitate, and have the head or knob divided longitudinally into three or four parts or laminæ. 7. Perfoliatæ, perfoliated, when the head or knob is divided horizontally. 8. Pectinatæ, pectinated, *i. e.* resembling a comb, when they have a longitudinal series of hairs projecting from them, in form of a comb. 9. Barbatæ, barbed, when they have little projections or barbs placed on their sides: they are either longiores, longer than the body; breviores, shorter than the body; or, me-

diocres, of the same length with the body.

Cuvier has shewn that the organs of hearing are placed at the base of the antennæ in the crustacea, such as crabs and lobsters, and from analogy many naturalists have supposed them to be similarly situated in the true insects; this may probably be correct, but it has not yet been proved, and must not therefore be assumed.

Clypeus, the covering of the head in the beetle tribe; it extends from the eyes, often projecting over the mouth.

Vertex, the top of the head above the front.

Front, this term is applied to the anterior part of the head of most insects, and is analogous to the clypeus of the beetles.

Gula, throat, underneath the head, supporting the lip.

Mouth, is situated in the head, rarely in the breast, and affords so great a variety of characters, that the celebrated Fabricius founded upon them his entire system of arrangement; the principal and most obvious parts are, the palpii, mandibulæ, labrum, labium, ligula, maxillæ, and galeæ.

Palpi, or feelers, are articulated filaments of different forms, sometimes resembling antennæ, placed in the mouth, either on the jaws or lip; they are two, or four, or six, in number, and are either anterior, intermediate, or posterior, or, according to Latreille, labial or maxillary. Considered in relation to those parts upon which they are situated, they generally furnish good generic characters.

Mandibulæ, mandibles, two horny curved pieces, placed one on each side of the mouth, moving laterally, and used by the insect either to seize its food, or as weapons in its combats.

Maxillæ, jaws, two horny or submembranaceous pieces, placed one under each mandible, generally ciliated with hair, or dentate on the inner side, and always palpigerous in those insects that have more than one pair of palpi.

Labrum, or as it is sometimes termed labium superius, upper lip, a transverse moveable piece, placed immediately below or underneath the clypeus and above the mandibles.

Labium, lip, termed by some entymologists labium inferius, and by others mentum, or chin, a horny substance, sometimes truncate, and terminates the mouth; beneath it supports the posterior palpi, and serves as a sheath for the tongue.

Ligula, a soft instrument, coriaceous at the base, often bifid at the tip, and retractile; this part is found only in insects provided with mandibles.

Galæ, casque, two membranaceous, inarticulate pieces, placed one on each side of the mouth in some insects of the hemiptera and neuroptera orders, and in conjunction with the lips covering the mouth; this part is by some considered as an anterior palpi, or an exterior division of the jaws.

In some insects the mouth is elongated into a tube, or placed at the end of a projection of the head, and is then either a lingua, proboscis, haustellum, rostellum, or rostrum.

Lingua, tongue, soft, flexible, tubular, involuted, like the spring of a watch, usually obtuse at its termination, and placed under the head between the palpi of the butterflies and moths.

Proboscis, trunk, soft, retractile, inarticulate, labiated at the extremity, and is peculiar to the flies; the common fly affords a good example of it.

Haustellum, sucker, composed of very fine and rigid filaments, enclosed in a bivalve sheath, and is peculiar to the cimices, and some of the flies.

Rostellum, a bill, or beak, coriaceous, articulate, and inclosing the haustellum.

Rostrum, a prolongation of the head, terminated by the mouth, as in the curculios, &c.

Some of these terms are not used by some authors as here defined; and indeed so unsettled are many entomological terms, that the student is often very much perplexed by the various applications of them.

II. Truncus, the trunk, to which the legs are attached, is situated between the head and the abdomen; it is divided into, 1. The thorax, or chest, which is the superior part. 2. Scutellum, *i. e.* small shield or escutcheon, separated from it by a suture, on the posterior part. 3. The breast and sternum, which is the inferior part.

III. The abdomen, that part which contains the stomach, intestines, and other viscera, consists of several annular segments; it is perforated on the sides with spiracula, or breathing-holes; the upper part of it is termed tergum, or back; the inferior part venter, or belly; the posterior part anus.

IV. Artus, the extremities, are the wings, legs, and tail.

(1.) Alæ, the wings, are two or four; they are either, 1. Planæ, *i. e.* plain, such

as cannot be folded up by the insect: or, 2. Plicatiles, or folding, such as can be folded up by the insect at pleasure. 3. Erectæ, erect, such as have their superior surfaces brought into contact, and stand upright when the insect is at rest. 4. Patentes, spreading; such as are extended horizontally. 5. Incumbentes, incumbent; such as rest on the upper part of the abdomen 6. Deflexæ, bent down; such as are partly incumbent, but have their exterior edge inclined towards the sides of the abdomen 7. Reversæ, reversed; such as are incumbent, but inverted. 8. Dentatæ, such as have their edges notched or serrated. 9. Caudatæ, such as have processes extended from their extremities like a tail. 10. Reticulatæ, netted; when the vessels of the wings put on the appearance of net-work. 11 Pictæ, painted; such as are marked with coloured spots, bands, streaks, lines, or dots. 12. Notatæ, marked with specks. 13. Ornatæ, adorned with little eyes, or circular spots, containing a spot of a different colour in their centre: the central spot is termed pupil; the exterior one is called iris; this may happen either in the primary or secondary wings, on their upper or under surfaces: the superior wing is called primary, and the inferior secondary, to avoid confusion, as they may be at times reversed. The elytra are hard shells, occupying the place of the upper wings. They are for the most part moveable, and are either, 1. Truncata, truncated, when shorter than the abdomen, and terminated by a transverse line. 2. Spinosa, or prickly, when their surfaces are covered with sharp points or prickles. 3. Serrata, serrated, when their edges are notched. 4. Scabra, rough, when their surface resembles a file. 5. Striata, striated, when marked with slender longitudinal furrows. 6. Porcata, ridged, when marked with elevated ridges. 7. Sulcata, furrowed. 8. Punctata, marked with dots. 9. Fastigiata, when formed like the roof of a house. The hemelytra, as it were half-elytra, partaking partly of the nature of crustaceous shells, and membranaceous wings, being formed of an intermediate substance. Halteres, or poisers, are small orbicular bodies placed on stalks, situated under the wings of insects, of the order Diptera.

(II.) Pedes, the legs, are divided into, 1. Femur, or thigh, that part which is joined to the trunk. 2. Tibia, or shank. 3. Tarsus, or foot. 4. Ungues, hooks or nails. 5. Manus, (chela,) hands or claws, simple, with a moveable thumb, as in the crab. The hind legs are termed, 1. Cursorii, formed for running. 2. Saltatorii, formed for leaping 3. Natatorii, formed for swimming.

(III.) Cauda, the tail, which terminates the abdomen, is 1. Solitaria, *i. e.* single. 2. Bicornis, *i. e.* two-horned, or double. 3. Simplex, simple, *i. e.* unarmed. 4. Armata, *i. e.* furnished: 1. with forceps or pincers: 2. with furca, a fork: 3. with one or more setæ, or bristles: 4 with an aculeus, or sting, either smooth or barbed. A sting is a weapon frequently hollow, with which some insects are furnished, and through which they discharge a poison into the wound they inflict.

The sexes of insects are commonly two, male and female. Neuters are to be met with among those insects which live in swarms, such as ants, bees, &c.

The majority of insects are observed to be annual, finishing the whole term of their lives in the space of a year or less, and many do not live half that time; nay, there are some which do not survive many hours; but this latter period is to be understood only of the animals when in their complete or ultimate form, for the larvæ of such as are of this short duration have in reality lived a very long time under water, of which they are natives; and it is observed, that water insects, in general, are of longer duration than land insects. Some few insects, however, in their complete state, are supposed to live a considerable time, as bees for instance; and it is well known that some of the butterfly tribe, though the major part perish before winter, will yet survive that season in a state of torpidity, and again appear and fly abroad in the succeeding spring; spiders are also thought to live a considerable time, and some species of the genus cancer are said to live several years, especially the common lobster, &c.: it should be observed, however, that these animsls, in the opinion of some modern naturalists, constitute a different tribe of beings from insects properly so called. Linnæus has divided insects into seven orders 1. COLEOPTERA; II. HEMIPTERA; III LEPIDOPTERA; IV. NEUROPTERA; V. HYMENOPTERA; VI. DIPTERA; VII. APTERA, which see: and from these the several genera are referred to.

ENTRY, in law, is the taking possession of lands or tenements, where the party has a title of entry, or an immediate right to possess them. This may be in person, or by attorney, or is an entry in law, which is merely the making con-

tinual claim, by law considered equivalent to entry. A right of entry is when a party may have his remedy, either by entering into the lands, or by action to recover it. A title of entry is where one has a lawful entry in the land which another has, but has no action to recover it till he has entered.

Entry is a summary remedy against certain species of injury by ouster, or putting out of possession of lands; when the party must make a formal but peaceable entry, declaring that he takes possession; or may enter upon any part in the same county in the name of the whole; and if he cannot go upon the land for bodily fear, he may make a claim as near the estate as he can, which must be repeated once within every year and day, and is called continual claim. This remedy is admitted only where the adverse possession originally commenced by wrong, as in the instances technically called abatement, intrusion, or disseisin. On a discontinuance or deforcement, the party is put to his action. Even in the former cases, when the original wrongful possessor dies, and the land comes to his heir, the right of entry is tolled, *i. e.* taken away by the descent. If the claimant was under disability, from age, coverture, &c. the entry is not tolled by descent; nor in case of an actual disseisin, unless the disseisor was in peaceable possession for five years. Stat. 32 Henry VIII. c. 33. Entry must be made within 20 years after the claimant's right shall accrue, 21 Jac. 1. c. 16; and by 4 and 5 Anne, c. 16, no entry shall avail to save this statute, unless an action is commenced and prosecuted with effect upon it within one year after; and, finally, by stat. 5 Ric. II. st. 1. c. 8, entry must be pursued in a peaceable manner; for if one turns or keeps another out of possession forcibly, it is not only the subject of a civil remedy, but of a fine and punishment for a misdemeanor.

Entry, *the writ of*, is a possessory remedy, which disproves the title of the tenant or possessor, by shewing the unlawful means by which he entered or continues in possession. It was formerly an usual mode of recovering lands, but is now disused for the more convenient action of ejectment, and is never brought when that remedy can be used. There is much nice technical learning concerning it, which it would be vain to attempt to abridge in a popular work. It derives different denominations from the different cases to which the writ is applied, and those are generally derived from the terms in which it states the wrongful entry to have been made, or sets out the different degrees of descent, through which the lands have passed in the possession of the wrongful tenants. After a certain degree of descents, these are no longer noticed in the writ. The writ against the immediate wrong doer is called a writ of entry in nature of assize: that upon one descent, an entry *sur disseisin* in the *per*; and upon an entry where the first disseisor has enfeoffed another, and he a third, it is an entry *sur disseisin in le per et eni*. An entry *in le post* states only that the tenant hath not entry but after (*post*) the disseisin of A. B. which is allowed in cases beyond the foregoing degrees. There are other writs adapted to particular cases, which we shall only mention by name, and refer to the larger dictionaries of the law for their precise meaning: such are

Entry *ad communem legem*, for the reversioner of tenants in dower by courtesy for life, &c.

Entry *ad terminum qui præteriit*, a writ for the reversioner, after the end of a term or estate for life, against a stranger in possession.

Entry *in casu consimili*.

Entry *in casu proviso*.

Entry *causa matrimonii prælocuti*.

Several points of law occur, as to the effect of an entry in the case of joint tenancy and coparcenary; of entry by the heir; of entry to divest an estate; to take advantage of a condition which cannot be investigated here; but in general it may be observed, that a bare entry, without expulsion, makes only a seisin; so that the law thereupon adjudges him in possession who has the right.

ENVELOPE, in fortification, a work of earth, sometimes in form of a simple parapet, and at others like a small rampart with a parapet: it is raised sometimes on the ditch, and sometimes beyond it.

ENVOY, a person deputed to negotiate some affair with any foreign prince or state. Those sent from the courts of France, Britain, Spain, &c. to any petty prince or state, such as the princes of Germany, the republics of Venice, Genoa, &c. go in quality of envoys, not embassadors, and such a character only do those persons bear, who go from any of the principal courts of Europe to another, when the affair they go upon is

not very solemn or important. There are envoys ordinary and extraordinary, as well as embassadors; they are equally the same under the protection of the law of nations, and enjoy all the privileges of embassadors, only differing from them in this, that the same ceremonies are not performed to them.

ENURE, in law, to take place or effect, or be available, as a release made to a tenant for a term of life shall enure to him in the reversion.

EPACRIS, in botany, a genus of the Pentandria Monogynia class and order. Calyx five-parted; corolla funnel-form, villous; nectariferous scales, growing to the germ; capsule five-celled, five-valved; the partitions from the middle of the valves; seeds minute and numerous. There are four species, natives of New Zealand.

EPACT, a number arising from the excess of the common solar year above the lunar, whereby the age of the moon may be found out every year. See CHRONOLOGY. The excess of the solar year above the lunar is 11 days; or the epact of any year expresses the number of days from the last new moon of the old year, which was the beginning of the present lunar year, to the first of January. The first year of the cycle of the moon, the epact is 0, because the lunar year begins with the solar. On the second, the lunar year has begun 11 days before the solar year, therefore the epact is 11. On the third, it has begun twice 11 before the solar year, therefore the epact is 22. On the fourth, it begins three times 11 days sooner than the solar year, the epact would therefore be 33; but 30 days, being a synodical month, must that year be intercalated; or that year must be reckoned to consist of thirteen synodical months, and there remains three, which is the true epact of the year; and so on to the end of the cycle, adding 11 to the epact of the last year, and always rejecting 30, gives the epact of the present year. Thus, to adjust the lunar year to the solar through the whole of 19 years, 12 of them must consist of 12 synodical months each, and 7 of 13, by adding a month of 30 days to every year when the epact would exceed 30, and a month of 29 days to the last year of the cycle, which makes in all 209 days, *i. e.* 19×11; so that the intercalary or embolimæan years in this cycle are 4, 7, 10, 12, 15, 18, 19.

If the new moons returned exactly at the same time after the expiration of nineteen years, as the council of Nice supposed they would do (when they fixed the rule for the observation of Easter, and marked the new moons in the calendar for each year of the lunar cycle) then the golden number, multiplied by 11, would always give the epact. But in a Julian century, the new moons anticipate, or happen earlier, than that council imagined they would by $\frac{8}{25}$ of a day. In a Gregorian common century, which is one day shorter than a Julian century, they happen $\frac{17}{25}$ of a day later. (1 day$-\frac{8}{25}=\frac{17}{25}$). Now $\frac{17}{25} \times 3 = \frac{51}{25}$ for the three common centuries, but $\frac{8}{25}$ being subtracted, on account of the Gregorian bissextile century, there will remain $\frac{43}{25}$. Therefore, in four Gregorian centuries, the new moons will happen later by $\frac{43}{25}$, of a day, and the epacts must be decreased accordingly.

At present the Gregorian epact is 11 days short of the Julian epact; but the quotient of the number of the centuries divided by 4, which at this time is 4, multiplied by $\frac{43}{25}$, with the addition of the remainder 1 multiplied by $\frac{17}{25}$, makes in all but $\frac{189}{25}$, or 7 days $+\frac{14}{25}$; therefore $\frac{86}{25}$, *i. e.* 3 days $+\frac{11}{25}$ must be added to complete the 11 days. Whence we have the following

General rule for finding the Gregorian Epact for ever. Divide the centuries of any year of the Christian æra by 4, (rejecting the subsequent numbers; multiply the remainder by 17, and to this product add the quotient multipled by 43: divide the product + 86 by 25: multiply the golden number by 11, from which subtract the last quotient; and rejecting the thirties, the remainder will be the epact.

Example for 1808.

$$18 \div 9 = 2$$
$$2 \times 17 = 34$$
$$43 \times 4 + 34 = 206$$
$$206 + 86 \div 25 = 11$$
$$11 \times 4 \text{ (Gold. No.)} = 44$$
$$\frac{44 - 11}{30} = 1 - 3 = \text{Epact.}$$

A shorter rule for finding the epact until the year 1900. Subtract 1 from the golden number, and multiplying the remainder by 11, reject the thirties, and you have the epact.

Example for the year 1808.

Golden Number 4.

$4 - 1 \times 11 - 30 = 3 =$ Epact.

EPAULE, in fortification, denotes the shoulder of a bastion, or the place where its face and flank meet, and form the angle called the angle of the shoulder. See BASTION.

EPAULEMENT, in fortification, a work raised to cover sideways, is either of earth, gabions, or fascines, loaded with earth. The epaulements of the places of arms for the cavalry, at the entrance of the trenches, are generally of fascines mixed with earth.

EPAULETTES, in military dress, are a sort of shoulder-knot. They are badges of distinction worn on one or both shoulders, according to the rank of the wearer, and for the same reason they are made either of worsted, or of silver or gold lace. In France, all degrees of rank in the army may be instantly known from the epaulette; but this is not the case here. Lately epaulettes have been introduced into the navy, and in that service the following are the gradations of rank as distinguished by them. Masters and commanders have one epaulette on the left shoulder: post captains under three years, one epaulette on the right shoulder, afterwards two epaulettes: rear admirals have one star on the strap of the epaulette, vice-admirals two stars, and admirals three stars.

EPHA, or EPHAH, in Jewish antiquity, a measure for things dry, containing 1.0961 of a bushel. See MEASURE.

EPHEDRA, in botany, a genus of the Dioecia Monodelphia class and order. Natural order of Coniferæ. Essential character: male, calyx of the ament two-cleft; corolla none; stamens seven; anthers four inferior, three superior: female, calyx two-parted, five-fold: corolla none; pistils two; seeds covered with a berried calyx. There are two species; *viz.* E. distachya, great shrubby horse tail, or sea-grape, and E. monostachya, small shrubby horse tail. These plants vary extremely. Some in the south of Europe, are only a hand in height, whilst others are three feet: they are found in most of the southern parts of the Russian dominions, from the Volga to the Lena, and southwards to Persia and India. The berries are sweetish, mucose, and leave a little heat in the throat: they are eaten by the Russian peasants, and the wandering hordes of all Great Tartary.

EPHEMERA, *day-fly*, in natural history, a genus of insects of the order Neuroptera. Mouth without mandibles; feelers four, very short, filiform; antennæ short, filiform; above the eyes are two or three large stemmata; wings erect, the lower ones much shorter; tail terminating in long bristles or hairs. These short-lived animals, of which there are about twenty species, in two divisions, according as they have two or three hairs in the tail, are found every where about waters in the summer, and in their perfect state seldom live more than a day or two, some of them not an hour, during which time they perform all the functions of life, and answer all the ends of nature. The larva lives under water, and is eagerly sought after by trout and other fish: it is six-footed, active, and furnished with a tail and six lateral fins or gills; the pupa resembles the larva, except in having rudiments of future wings. The larva is altogether aquatic, the complete insect aerial. In the former state it lives two or three years; but as a perfect animal it survives but a very few hours, perishing in the course of the same evening that gives it birth. The most common species in Europe is the E. vulgata, or common May-fly, so plentiful in the early part of summer about the brinks of rivulets and stagnant waters. It is of a greenish colour, with transparent wings elegantly mottled with brown, and is furnished with three very long black bristles. It flutters in the evening about the surface of the water; but during the day is generally seen in a quiescent posture, with the wings closed, and applied to each other in an upright position.

EPHEMERIDES, in literary history, an appellation given to those books or journals, which shew the motions and places of the planets for every day in the year. It is from the tables contained in these ephemerides, that eclipses, and all the variety of aspects of the planets, are found.

EPHIELIS, in botany, a genus of the Octandria Monogynia class and order. Esential character: calyx five-parted; petals five, with claws; nectary ten scales, two to each petal; capsule oblong, one celled, two-valved, two-seeded. There is but one species; *viz.* E. guianensis: this is a lofty tree growing in the forests of Guiana, where it flowers in the month of October.

EPIBATERIUM, in botany, a genus of the Monoecia Hexandria class and or-

der. Essential character: calyx double; outer six-leaved, small; inner three-leaved, large; petals six, three outer, between the calycine leaflets; three inner; drupes three, subglobular, mucronate, with three permanent styles; inclosing a kidney-form nut. There is only one species; *viz.* E. pendulum.

EPIC, or *heroic poem*, a poem expressed in narration, formed upon a story partly real and partly feigned; representing, in a sublime style, some signal and fortunate action, distinguished by a variety of great events, to form the morals, and affect the mind with the love of heroic virtue.

EPICHRYSUM, in botany, a genus of the Cryptogamia Fungi class and order. Fungus rounded, concave; seeds globular; tailless, attached to a branched thread creeping within. There is but one species; *viz* E. argenteum.

EPICUREAN *philosophy*, the doctrine or system of philosophy maintained by Epicurus and his followers.

Epicurus, the Athenian, one of the greatest philosophers of his age, was obliged to Democritus for almost his whole system, notwithstanding he piqued himself upon deriving every thing from his own fund. He wrote a great number of books, which are made to amount to above 300. Though none of them are come down to us, no ancient philosopher's system is better known than his, for which we are mostly indebted to the poet Lucretius, D ogenes, Laertius, and Tully. His philosophy consisted of three parts, canonical, physical, and ethereal. The first was about the canons, or rules of judging. The censure which Tully passes upon him, for his despising logic, will hold true only with regard to the logic of the Stoics, which he could not approve of, it being too full of nicety and quirk. Epicurus was not acquainted with the analytical method of division and argumentation, nor was he so curious in modes and formation, as the Stoics. Soundness and simplicity of sense, assisted with some natural reflections, was all his art. His search after truth proceeded only by the senses, to the evidence of which he gave so great a certainty, that he considered them as an infallible rule of truth, and termed them the first natural light of mankind.

In the second part of his philosophy he laid down atoms, space, and gravity, as the first principles of all things. He did not deny the existence of a God, but thought it beneath his majesty to concern himself with human affairs. He held him a blessed immortal being, having no affairs of his own to take care of, and above meddling with those of others. See ATOMIC PHILOSOPHY.

As to his ethics, he made the supreme good of man to consist in pleasure, and, consequently, supreme evil in pain. Nature itself, says he, teaches us this truth, and prompts us from our birth to procure what ever gives us pleasure, and avoid what gives us pain. To this end he proposes a remedy against the sharpness of pain: this was to divert the mind from it, by turning our whole attention upon the pleasures we have formerly enjoyed. He held that the wise man must be happy, as long as he is wise; that pain, not depriving him of his wisdom, cannot deprive him of his happiness.

EPICYCLE, in the ancient astronomy, a little circle, whose centre is in the circumference of a greater circle; or it is a small orb or sphere, which, being fixed in the deferent of a planet, is carried along with it; and yet, by its own peculiar motion, carries the planet fastened to it round its proper centre.

It was by means of epicycles, that Ptolemy and his followers solved the various phenomena of the planets, but more especially their stations and retrogradations. The great circle they called the excentric or deferent, and along its circumference the center of the epicycle was conceived to move; carrying with it the planet fixed in its circumference, which in its motion downwards proceeded according to the order of the signs, but in moving upwards contrary to that order. The highest point of a planet's epicycle they called apogee, and the lowest perigee.

EPICYCLOID, in geometry, a curve generated by the revolution of the periphery of a circle, A C E (Plate V Miscel. fig. 4) along the convex or concave side of the periphery of another circle, D G B.

The length of any part of the curve, that any given point in the revolving circle has described, from the time it touched the circle it revolved upon, shall be to double the versed sine of half the arch which all that time touched the circle at rest, as the sum of the diameters of the circles to the semidiameter of the resting circle, if the revolving circle moves upon the convex side of the resting cir-

cle; but if upon the concave side, as the difference of the diameters to the semidiameter of the resting circle.

In the Philosoph. Transactions, No. 218, we have a general proposition for measuring the areas of all cycloids and epicycloids, *viz.* The area of any cycloid or epicycloid is to the area of the generating circle, as the sum of double the velocity of the centre and velocity of the circular motion to the velocity of the circular motion: and in the same proportion are the areas of segments of those curves to those of analogous segments of the generating circle.

EPIDEMIC. A contagious disease is so termed that attacks many people at the same season, and in the same place; thus, putrid fever, plague, dysentery, &c. are often epidemic. Dr. James Sims observes, in the Memoirs of the Medical Society of London, that there are some grand classes of epidemics which prevail every year, and which are produced by the various changes of the seasons. Thus, spring is accompanied by inflammatory diseases; summer by complaints in the stomach and bowels; autumn by catarrhs; and winter by intermittents. These being obviously produced by the state of weather attendant upon them, other epidemics are supposed analogous to them, and obedient to the same rules, which, on examination, not being the case, all further scrutiny is laid aside, perhaps too hastily.

The most natural and healthful seasons in this country are, a moderately frosty winter, showery spring, dry summer, and rainy autumn; and whilst such prevail, the wet part of them is infested by vastly the greatest proportion of complaints, but those not of the most mortal kind. A long succession of wet seasons is accompanied by a prodigious number of diseases; but these being mild and tedious, the number of deaths are not in proportion to the co-existent ailments. On the other hand, a dry season, in the beginning, is attended with extremely few complaints, the body and mind both seeming invigorated by it; if, however, this kind of weather last very long, towards the close of it a number of dangerous complaints spring up, which, as they are very short in their duration, the mortality is much greater than one would readily suppose, from the few persons that are ill at any one time: and as soon as a wet season succeeds a long dry one, a prodigious sickness and mortality come on universally. So long as this wet weather continues, the sickness scarcely abates, but the mortality diminishes rapidly; so that in the last number of rainy years the number of deaths is at the minimum. The change of a long dry season, whether hot or cold, to a rainy one, appears to bring about the temperature of air favourable to the production of great epidemics. Some, however, seem more speedily to succeed the predisposing state of the air, others less so; or it may be, that the state of the air favourable to them exists at the very beginning of the change, whilst the state favourable to others progressively succeeds: of this last, however, Dr. Sims is very uncertain.

Two infectious diseases, it appears, are hardly ever prevalent together; therefore, although the same distemperature of air seems favourable to most epidemic disorders, yet some must appear sooner, others later. From observation and books, the Doctor describes the order in which these disorders have a tendency to succeed each other to be, plague, petechial fever, putrid sore throat, with or without scarlatina, dysentery, small-pox, measles, simple scarlatina, hooping-cough, and catarrh: "I do not mean by this," says he, "that they always succeed each other as above; for often the individual infection is wanting, when another takes its place, until perhaps that infection is imported from a place, which has been so unfortunate as to have a co-incidence of the two causes, without which it appears that no epidemic can take place: that is, a favourable disposition of the air, and that particular infection. Whenever it happens that one infectious disorder takes the plaee that should have been more properly occupied by another, it becomes much more virulent than it is naturally, whilst the former, if it afterwards succeeds, becomes milder in proportion: this, perhaps, is the reason why the same disorders, nay, the same appearance in a disorder, are attended with much more fatality in one year than another."

EPIDENDRUM, in botany, a genus of the Gynandria Diandria class and order. Natural order of Orchideæ. Essential character: nectary turbinate, oblique, reflex; corolla spreading; spur none, There are 124 species. This numerous genus is obscure in its character, differences, and synonyms: for the flowers in dried specimens can hardly be unfolded; the plants are cultivated in gardens with difficulty; and the species have not been sufficiently described by authors, who

have had an opportunity of seeing them in America and the East Indies, their native places of growth.

EPIDERMIS, in anatomy, the same with the cuticle. See CUTIS.

EPIGÆA, in botany, a genus of the Decandria Monogynia class and order. Natural order of Bicornes. Ericæ, Jussieu. Essential character: calyx outer three-leaved; inner five-parted; corolla salver-form; capsule five-celled. There are but two species, *viz.* E. repens, creeping epigæa, or trailing arbutus, and E. cordifolia, heart-leaved epigæa: the former, remarkable for its fine odour, is a native of Virginia and Canada, and the latter of Guadaloupe.

EPIGLOTTIS, one of the cartilages of the larynx or wind-pipe. See ANATOMY.

EPIGRAM, in poetry, in short poem or composition in verse, treating only of one thing, and ending with some lively, ingenious, and natural thought or point.

EPILEPSY, in medicine, the same with what is otherwise called the falling sickness, from the patient's falling suddenly to the ground.

EPILOBIUM, in botany, a genus of the Octandria Monogynia class and order. Natural order of Calycanthemæ. Onagræ, Jussieu. Essential character: calyx four-cleft; petals four; capsule oblong, inferior; seeds downy. There are fourteen species. These plants are hardy perennials, not void of beauty; they are, however, commonly considered only as weeds, and are rarely cultivated in gardens. The American species are, 1. E. estoratum; 2. E. spicatum; 3. E. strictum; 4. E. linerate.

EPILOGUE, in dramatic poetry, a speech addressed to the audience after the play is over, by one of the principal actors therein, usually containing some reflections on certain incidents in the play, especially those in the part of the person that speaks it.

EPIMEDIUM, in botany, English *barrenwort*, a genus of the Tetrandria Monogynia class and order. Natural order of Corydales. Berberides, Jussieu. Essential character: nectary four, cup-form, leaning on the petals; corolla four petalled; calyx very caducous; fruit a silique. There is but one species, *viz.* E. alpinum, alpine barrenwort.

EPIPHANY, a christian festival, otherwise called the manifestation of Christ to the Gentiles, observed on the sixth of January, in honour of the appearance of our Saviour to the three magi, or wise men, who came to adore him, and bring him presents. The feast of Epiphany was not originally a distinct festival, but made a part of that of the nativity of Christ, which being celebrated twelve days, the first and last of which were high or chief days of solemnity, either of these might properly be called Epiphany, as that word signifies the appearance of Christ in the world.

The kings of England and Spain offer gold, frankincense, and myrrh, on Epiphany, or twelfth day, in memory of the offerings of the wise men to the infant Jesus.

The festival of Epiphany is called by the Greeks the feast of lights, because our Saviour is said to have been baptised on this day; and baptism is by them called illumination.

EPISCOPALIANS, in the modern acceptation of the term, belong more especially to members of the Church of England, and derive this title from episcopus, the Latin word for bishop; or, if it be referred to its Greek origin, implying the care and diligence with which bishops are expected to preside over those committed to their guidance and direction. They insist on the divine origin of their bishops, and other church officers, and on the alliance between church and state. Respecting these subjects, however, Warburton and Hoadley, together with others of the learned amongst them, have different opinions, as they have also on the thirty-nine articles, which were established in the reign of Queen Elizabeth. These are to be found in most Common Prayer-Books; and the Episcopal Church in America has reduced their number to twenty. By some the articles are made to speak the language of Calvinism, and by others they have been interpreted in favour of Arminianism.

The Church of England is governed by the King, who is the supreme head: by two archbishops, and twenty-four bishops. The benefices of the bishops were converted by William the Conqueror into temporal baronies; so that every prelate has a seat and vote in the House of Peers. Dr. Benjamin Hoadley, however, in a sermon preached from this text, "My kingdom is not of this world," insisted that the clergy had no pretensions to temporal jurisdiction, which gave rise to various publications, termed, by way of eminence, the Bangorian Controversy, Hoadley being then bishop of Bangor. There is a bishop of Sodor and Man, who has no seat in the House of Peers.

Since the death of the intolerant Archbishop Laud, men of moderate principles have been raised to the see of Canterbury, and this hath tended not a little to the tranquillity of church and state. The established Church of Ireland is the same as the Church of England, and is governed by four archbishops, and eighteen bishops.

EPISODE, in poetry. a separate incident, story or action, which a poet invents and connects with his principal action, that his work may abound with a greater diversity of events; though, in a more limited sense, all the particular incidents whereof the action or narration is compounded are called episodes.

EPITAPH, a monumental inscription in honour or memory of a person defunct, or an inscription engraven or cut on a tomb, to mark the time of a person's decease, his name, family, and, usually, some eulogium of his virtues, or good qualities.

EPITHALAMIUM, in poetry, a nuptial song, or composition, in praise of the bride and bridegroom, praying for their prosperity, for a happy offspring, &c.

EPITHET, in poetry and rhetoric, an adjective expressing some quality of a substantive to which it is joined; or such an adjective as is annexed to substantives by way of ornament and illustration, not to make up an essential part of the description. "Nothing," says Aristotle, "tires the reader more than too great a redundancy of epithets, or epithets placed improperly; and yet nothing is so essential in poetry as a proper use of them."

EPITOME, in literary history, an abridgment or summary of any book, particularly of a history.

EPOCHA, in chronology, a term or fixed point of time, whence the succeeding years are numbered or accounted. See CHRONOLOGY.

EPODE, in lyric poetry, the third or last part of the ode, the ancient ode being divided into strophe, antistrophe, and epode.

EPOPOEIA, in poetry, the story, fable, or subject, treated of in an epic poem. The word is commonly used for the epic poem itself. See EPIC.

EPSOM *salt*, another name for sulphate of magnesia.

EQUABLE, an appellation given to such motions as always continue the same in degree of velocity, without being either accelerated or retarded. When two or more bodies are uniformly accelerated or retarded, with the same increase or diminution of velocity in each, they are said to be equally accelerated, or retarded.

EQUAL, a term of relation between two or more things of the same magnitude, quantity, or quality. Mathematicians speak of equal lines, angles, figures, circles, ratios, solids, &c.

EQUALITY, that agreement between two or more things whereby they are denominated equal. The equality of two quantities, in algebra, is denoted by two parallel lines placed between them; thus, $4 + 2 = 6$, that is, 4 added to 2 is equal to 6.

EQUANIMITY, in ethics, denotes that even and calm frame of mind and temper, under good or bad fortune, whereby a man appears to be neither puffed up or overjoyed with prosperity, nor dispirited, soured, or rendered uneasy, by adversity.

EQUATION, in algebra, the mutual comparing two equal things of different denominations, or the expression denoting this equality; which is done by setting the one in opposition to the other, with the sign of equality ($=$) between them: thus, $3s. = 36d.$ or 3 feet $=$ 1 yard. Hence, if we put a for a foot, and b for a yard, we shall have the equation $3a = b$, in algebraical characters. See ALGEBRA.

EQUATIONS, *construction of*, in algebra, is the finding the roots or unknown quantities of an equation, by geometrical construction of right lines or curves, or the reducing given equations into geometrical figures. And this is effected by lines or curves, according to the order or rank of the equation. The roots of any equation may be determined, that is, the equation may be constructed, by the intersections of a straight line with another line or curve of the same dimensions as the equation to be constructed: for the roots of the equation are the ordinates of the curve at the points of intersection with the right line; and it is well known that a curve may be cut by a right line in as many points as its dimensions amount to. Thus, then, a simple equation will be constructed by the intersection of one right line with another; a quadratic equation, or an affected equation of the second rank, by the intersections of a right line with a circle, or any of the conic sections, which are all lines of the second order; and which may be cut by the right line in two points, thereby giving the two roots of the quadratic equation. A cubic equation may be constructed by

the intersection of the right line with a line of the third order, and so on. But if, instead of the right line, some other line of a higher order be used, then the second line, whose intersections with the former are to determine the roots of the equation, may be taken as many dimensions lower as the former is taken higher. And, in general, an equation of any height will be constructed by the intersection of two lines, whose dimensions multiplied together produce the dimension of the given equation. Thus, the intersections of a circle with the conic sections, or of these with each other, will construct the biquadratic equations, or those of the fourth power, because $2 \times 2 = 4$; and the intersections of the circle, or conic sections, with a line of the third order, will construct the equations of the fifth and sixth power, and so on.—For example:

To construct a simple equation. This is done by resolving the given simple equation into a proportion, or finding a third or fourth proportional, &c. Thus, 1. If the equation be $a x = b c$; then $a : b :: c : x = \frac{b c}{a}$, the fourth proportional to a, b, c. 2. If $a x = b$; then $a : b :: b : x = \frac{b^2}{a}$, a third proportional to a and b. 3. If $a x = b^2 - c^2$; then, since $b^2 - c^2 = \overline{b + c} \times \overline{b - c}$, it will be $a : b + c :: b - c : x = \frac{\overline{b + c} \times \overline{b - c}}{a}$, a fourth proportional to a, $b + c$, and $b - c$. 4. If $a x = b^2 + c^2$; then construct the right-angled triangle ABC (Plate V. Miscel. fig. 5.) whose base is b, and perpendicular is c, so shall the square of the hypothenuse be $b^2 + c^2$, which call h^2; then the equation is $ax = h^2$, and $= \frac{h^2}{a}$, a third proportional to a and h.

To construct a quadratic equation. 1. If it be a simple quadratic, it may be reduced to this form, $x^2 = a b$; and hence $a : x :: x : b$, or $x = \sqrt{a b}$, a mean proportional between a and b. Therefore upon a straight line take A B $= a$, and B C $= b$; then upon the diameter A C describe a semicircle, and raise the perpendicular B D to meet it in D; so shall B D be $= x$, the mean proportional sought between A B and B C, or between a and b. 2. If the quadratic be affected, let it first be $x^2 + 2 ax = b^2$; then form the right-angled triangle, whose base A B is a, and perpendicular B C is b; and with the centre A and radius A C describe the semicircle D C E; so shall D B and B E be the two roots of the given quadratic equation $x^2 + 2 a x = b^2$. 3. If the quadratic be $x^2 - 2 a x = b^2$, then the construction will be the very same as of the preceding one $x^2 + 2 a x = b^2$. 4. But if the form be $2 a x - x^2 = b^2$, form a right-angled triangle (fig. 1.) whose hypothenuse F G is a, and perpendicular G H is b; then with the radius F G and centre F describe a semicircle I G K; so shall I H and H K be the two roots of the given equation $2 a x - x^2 = b^2$, or $x^2 - 2 a x = - b^2$.

To construct cubic and biquadratic equations. These are constructed by the intersections of two conic sections; for the equation will rise to four dimensions, by which are determined the ordinates from the four points in which these conic sections may cut one another; and the conic sections may be assumed in such a manner as to make this equation coincide with any proposed biquadratic; so that the ordinates from these four intersections will be equal to the roots of the proposed biquadratic. When one of the intersections of the conic section falls upon the axis, then one of the ordinates vanishes, and the equation by which these ordinates are determined will then be of three dimensions only, or a cubic to which any proposed cubic equation may be accommodated; so that the three remaining ordinates will be the roots of that proposed cubic. The conic sections for this purpose should be such as are most easily described; the circle may be one, and the parabola is usually assumed for the other. See Simpson's and Maclaurin's Algebra.

Equations, *nature of.* Any equation involving the powers of one unknown quantity may be reduced to the form $z^n - p z^{n-1} + q z^{n-2}$, &c. $= 0$, here the whole expression is equal to nothing, and the terms are arranged according to the dimensions of the unknown quantity, the coefficient of the highest dimension is unity, understood, and the coefficients p, q, r, and are effected with the proper signs. An equation, where the index is of the highest power of the unknown quantity is n, is said to be of n dimensions, and in speaking simply of an equation of n dimensions, we understand one reduced to the above form. Any quantity $z^m - p z^{n-1} + q z^{n-2}$, &c. $+ P z - Q$ may be supposed to arise from the multiplication of $z - a \times \overline{z - b} \times \overline{z - c}$, &c.

to n factors. For by actually multiplying the factors together, we obtain a quantity of n dimensions similar to the proposed quantity $z^n - p\,z^{n-1} + q\,z^{n-2}$, &c.; and if a, b, c, &c. can be so assumed, that the coefficients of the corresponding terms in the two quantities become equal, the whole expressions coincide. And these coefficients may be made equal, because these will be n equations, to determine n quantities, a, b, c, &c. If then the quantities, a, b, c, &c. be properly assumed, the equation $z^n - p\,z^{n-1} + q\,z^{n-2}$, &c. $= 0$, is the same with $\overline{z-a} \times \overline{z-b} \times \overline{z-c}$, &c. $= 0$. The quantities a, b, c, d, &c. are called roots of the equation, or values of z; because, if any one of them be substituted for z, the whole expression becomes nothing, which is the condition proposed by the equation.

Every equation has as many roots as it has dimensions. If $z^n - p\,z^{m-1} + p\,z^{n-2}$, &c. $= 0$, or $\overline{z-a} \times \overline{z-b} \times \overline{z-c}$, &c. to n factors $= 0$, there are n quantities, a, b, c, &c. each of which when substituted for z makes the whole $= 0$, because in each case one of the factors becomes $= 0$; but any given quantity different from these, as e when substituted for z, gives the product $\overline{e-a} \times \overline{e-b} \times \overline{e-c}$, &c. which does not vanish, because none of the factors vanish, that is, e will not answer the condition which the equation requires.

When one of the roots, a, is obtained, the equation $\overline{z-a} \times \overline{z-b} \times \overline{z-c}$, &c. $= 0$, $z^n - p\,z^{n-1} + q\,z^{n-2}$, &c. $= 0$ is divisible by $z - a$ without a remainder, and is thus reducible to $\overline{z-b} \times \overline{z-c}$, &c. — 0, an equation one dimension lower, whose roots are b and c.

Ex. One root of $x^3 + 1 = 0$, or $x + 1 = 0$, and the equation may be depressed to a quadratic in the following manner:

$$\begin{array}{l}
x+1)\,x^3+1\,(x^2-x+1 \\
\quad\;\; x^3+x^2 \\
\quad\;\; \overline{\quad\quad\quad} \\
\quad\;\; -x^2 \\
\quad\;\; -x^2-x \\
\quad\;\; \overline{\quad\quad\quad\quad\quad} \\
\quad\quad\quad\quad +x+1 \\
\quad\quad\quad\quad\;\;\; x+1 \\
\quad\quad\quad\quad \overline{\quad\quad\quad} \\
\quad\quad\quad\quad\;\; \cdot\;\cdot
\end{array}$$

Hence the other two roots are the roots of the quadratic $x^2 - x + 1 = 0$. If two roots, a and b, be obtained, the equation is divisible by $\overline{x-a} \times \overline{x-b}$, and may be reduced in the same manner two dimensions lower.

Ex. Two roots of the equation $z^6 - 1 = 0$, are $+1$ and -1, or $z - 1 = 0$, and $z + 1 = 0$; therefore it may be depressed to a biquadratic by dividing by $\overline{z-1} \times \overline{z+1} = z^2 - 1$.

$$\begin{array}{l}
z^2-1)\,z^6-1\,(z^4+z^2+1 \\
\quad\quad\;\; z^6-z^4 \\
\quad\quad\;\; \overline{\quad\quad\quad} \\
\quad\quad\;\; +z^4 \\
\quad\quad\quad\; z^4-z^2 \\
\quad\quad\quad\; \overline{\quad\quad\quad\quad} \\
\quad\quad\quad\quad +z^2-1 \\
\quad\quad\quad\quad +z^2-1 \\
\quad\quad\quad\quad \overline{\quad\quad\quad} \\
\quad\quad\quad\quad\;\; \cdot\;\cdot
\end{array}$$

Hence the equation $z^4 + z^2 + 1 = 0$ contains the other four roots of the proposed equation.

Conversely, if the equation be divisible by $x - a$ without a remainder, a is a root; if by $\overline{x-a} \times \overline{x-b}$, a and b are both roots. Let Q be the quotient arising from the division, then the equation is $\overline{x-a} \times \overline{x-b} \times Q = 0$, in which, if a or b be substituted for x, the whole vanishes.

Equations, *cubic solution of, by Cardan's rule.* Let the equation be reduced to the form $x^3 - q\,x + r = 0$, where q and r may be positive or negative.

Assume $x = a + b$, then the equation becomes $\overline{a+b}|^3 - q \times \overline{a+b} + r = 0$, or $a^3 + b^3 + 3\,a\,b \times \overline{a+b} - q \times \overline{a+b} + r = 0$; and since we have two unknown quantities, a and b, and have made only one supposition respecting them, *viz.* that $a + b = x$, we are at liberty to make another; let $3\,a\,b - q = 0$, then the equation becomes $a^3 + b^3 + r = 0$; also, since $3\,a\,b - q = 0$, $b = \frac{q}{3\,a}$, and by substitution, $a^3 + \frac{q^3}{27\,a^3} + r = 0$, or $a^6 + r\,a^3 + \frac{q^3}{27} = 0$, an equation of a quadratic form; and by completing the

square, $a^6 + r\,a^3 + \frac{r^2}{4} = \frac{r^2}{4} + \frac{q^3}{27}$, and $a^3 + \frac{r}{2} = \pm\sqrt{\frac{r^2}{4} - \frac{q^3}{27}}$; therefore $a^3 = -\frac{r}{2} \pm \sqrt{\frac{r^2}{4} - \frac{q^3}{27}}$, and $a =$

$\sqrt[3]{-\frac{r}{2} \pm \sqrt{\frac{r^2}{4} - \frac{q^3}{27}}}$. Also, since $a^3 + b^3 + r = 0$, $b^3 = -\frac{r}{2} \pm \sqrt{\frac{r^2}{4} - \frac{q^3}{27}}$, and $b = \sqrt[3]{-\frac{r}{2} \pm \sqrt{\frac{r^2}{4} - \frac{q^3}{27}}}$; therefore $x = a + b = \sqrt[3]{-\frac{r}{2} \pm \sqrt{\frac{r^2}{4} - \frac{q^3}{27}}} + \sqrt[3]{-\frac{r^2}{4} \pm \sqrt{\frac{r^2}{4} - \frac{q^3}{27}}}$.

We may observe that when the sign of $\sqrt{\frac{r^2}{4} - \frac{q^3}{27}}$, in one part of the expression, is positive, it is negative in the other, that is $x = \sqrt[3]{-\frac{r}{2} - \sqrt{\frac{r^2}{4} - \frac{q^2}{27}}} + \sqrt[3]{-\frac{r}{2} - \sqrt{\frac{r^2}{4} - \frac{q^3}{27}}}$.

Since $b = \frac{q}{3a}$, the value of x is also $\sqrt[3]{-\frac{r}{2} - \pm\sqrt{\frac{r^2}{4} - \frac{q^3}{27}}} +$

$3\sqrt[3]{-\frac{r}{2} \pm \sqrt{\frac{r^2}{4} - \frac{q^3}{27}}}$.

Ex. Let $x^3 + 6x - 20 = 0$; here $q = -6$, $r = -20$, $x = \sqrt[3]{10 + \sqrt{108}} + \sqrt[3]{10 - \sqrt{108}} = 2.732 - .732 = 2.$

Cor. 1. Having obtained one value of x, the equation may be depressed to a quadratic, and the other roots found.

Cor. 2. The possible values of a and b being discovered, the other roots are known without the solution of a quadratic.

The values of the cube roots of a^3 are a, $\frac{-1+\sqrt{-3}}{2}a$, and $\frac{-1-\sqrt{-3}}{2}a$; and the values of the cube root of b^3 are b, $\frac{-1+\sqrt{-3}}{2}b$, $\frac{-1-\sqrt{-3}}{2}b$.

Hence it appears, that there are nine values of $a + b$, three only of which can answer the conditions of the equation, the others having been introduced by involution. These nine values are,

1. $a + b$.
2. $a + \frac{-1+\sqrt{-3}}{2}b$.
3. $a + \frac{-1-\sqrt{-3}}{2}b$.
4. $\frac{-1+\sqrt{-3}}{2}a + b$.
5. $\frac{-1+\sqrt{-3}}{2}a + \frac{-1+\sqrt{-3}}{2}b$.
6. $\frac{-1+\sqrt{-3}}{2}a + \frac{-1-\sqrt{-3}}{2}b$.
7. $\frac{-1-\sqrt{-3}}{2}a + b$.
8. $\frac{-1-\sqrt{-3}}{2}a + \frac{-1+\sqrt{-3}}{2}b$.
9. $\frac{-1-\sqrt{-3}}{2}a + \frac{-1-\sqrt{-3}}{2}b$.

In the operation we assume $3\,a\,b = q$, that is, the product of the corresponding values of a and b is supposed to be possible. This consideration excludes the 2d. 3d. 4th. 5th. 7th. and 9th. values of $a + b$, or x; therefore the three roots of the equation are

$a+b$; $\frac{-1+\sqrt{-3}}{2}a + \frac{-1-\sqrt{-3}}{2}b$; and $\frac{-1-\sqrt{-3}}{2}a + \frac{-1+\sqrt{-3}}{2}b$.

Cor. 3. This solution only extends to those cases in which the cubic has two impossible roots.

For if the roots be $m + \sqrt{3n}$, $m - \sqrt{3n}$, and $-2.m$, then $-q$ (the sum of the

products of every two with their signs changed) $= -3m^2 - 3n$, and $\frac{q}{3} = m^2 + n$; also, r (the product of all the roots with their signs changed) $= 2m^3 - 6mn$, and $\frac{r}{2} = m^3 - 3mn$; and by involution,

$$\frac{r^2}{4} = m^6 - 6m^4 n + 9m^2 n^2$$

$$\frac{q^3}{27} = m^6 + 3m^4 n + 3m^2 n^2 + n^2 - n^3$$

Hence, $\frac{r^2}{4} - \frac{q^3}{27} = -9m^4 n + 6m^2 n^2 - n^3 = -n \times \overline{9m^4 - 6m^2 n + n^2}$, and $\sqrt{\frac{r^2}{4} - \frac{q^3}{27}} = \sqrt{-n} \times \overline{3m^2 - n}$, a quantity manifestly impossible, unless n be negative, that is, unless two roots of the proposed cubic be impossible.

Equations, *biquadratic, solution of, by Des Cartes's method.* Any biquadratic may be reduced to the form $x^4 + qx^2 + rx + s = 0$, by taking away the second term. Suppose this to be made up of the two quadratics, $x^2 + ex + f = 0$, and $x^2 - ex + g = 0$, where $+e$ and $-e$ are made the coefficients of the second terms, because the second term of the biquadratic is wanting, that is, the sum of its roots is 0. By multiplying these quadratics together we have $x^4 + \overline{g + f - e^2} \,.\, x^2 + \overline{eg - ef} \,.\, x + fg = 0$, which equation is made to coincide with the former by equating their coefficients, or making $g + f - e^2 = q$, $eg - ef = r$, and $fg = s$; hence, $g + f = q + e^2$, also $g - f = \frac{r}{e}$, and by taking the sum and difference of these equations, $2g = q + e^2 + \frac{r}{e}$, and $2f = q + e^4 - \frac{r}{e}$; therefore $4fg = q^2 + 2qe^2 + e^4 - \frac{r^2}{e^2} = 4s$, and multiplying by e^2, and arranging the terms according to the dimensions of e, $e^6 + 2qe^4 + \overline{q^2 - 4s} \times e^2 - r^2 = 0$; or making $y = e^2$, $y^3 + 2qy^2 + \overline{q^2 - 4s}\, y - r^2 = 0$.

By the solution of this cubic, a value of y, and therefore of $\sqrt{y}$, or e, is obtained; also f and g, which are respectively equal to $\frac{q + e^2 - \frac{r}{e}}{2}$ and $\frac{q + e^2 + \frac{r}{e}}{2}$, are known; the biquadratic is thus resolved into two quadratics, whose roots may be found.

It may be observed, that whichever value of y is used, the same values of x are obtained.

This solution can only be applied to those cases, in which two roots of the biquadratic are possible, and two impossible.

Let the roots be $a, b, c, -\overline{a + b + c}$; then since e, the coefficient of the second term of one of the reducing quadratics, is the sum of two roots, its different values are $a + b$, $a + c$, $b + c$, $-\overline{a + b}$, $-\overline{a + c}$, $-\overline{b + c}$, and the values of e^2, or y, are $\overline{a + b}|^2$, $\overline{a + c}|^2$, $\overline{b + c}|^2$; all of which being possible, the cubic cannot be solved by any direct method. Suppose the roots of the biquadratic to be $a + b\sqrt{-1}$; $a - b\sqrt{-1}$; $-a + c\sqrt{-1}$; $-a - c\sqrt{-1}$; the values of e are $2a$, $\overline{b + c} \,.\, \sqrt{-1}$, $\overline{b - c} \,.\, \sqrt{-1}$, $-\overline{b - c} \,.\, \sqrt{-1}$, $-\overline{b + c} \,.\, \sqrt{-1}$ and $-2a$; and the three values of y are $\overline{2a}|^2$, $-\overline{b + c}|^2$, $-\overline{b - c}|^2$, which are all possible, as in the preceding case. But if the roots of the biquadratic be $a + b\sqrt{-1}$, $a - b\sqrt{-1}$, $-a + c$, $-a - c$, the values of y are $\overline{2a}|^2$, $\overline{c + b\sqrt{-1}}|^2$, $\overline{c - b\sqrt{-1}}|^2$, two of which are impossible; therefore the cubic may be solved by Cardan's rule.

Equation, *annual*, of the mean motion of the sun and moon's apogee and nodes. The annual equation of the sun's mean motion depends upon the excentricity of the earth's orbit round him, and is $16\frac{11}{12}$ such parts, of which the mean distance between the sun and the earth is 1000; whence some have called it the equation of the centre, which, when greatest, is 1° 56′ 20″.

The equation of the moon's mean motion is 11′ 40″; of the apogee, 20′; and of its node, 9′ 30″.

These four annual equations are always mutually proportionable to each other; so that when any of them is at the greatest, the three others will also be greatest; and when one diminishes, the rest diminish in the same ratio. Wherefore the annual equation of the centre of the sun being given, the other three corresponding equations will be given, so that one table of the central equations will serve for all.

Equation *of a curve*, is an equation shewing the nature of a curve by expressing the relation between any absciss and

its corresponding ordinate, or else the relation of their fluxions, &c. Thus, the equation to the circle is $a x - x^2 = y^2$, where a is its diameter, x any absciss or part of that diameter, and y the ordinate at that point of the diameter; the meaning being, that whatever absciss is denoted by x, then the square of its corresponding ordinate will be $a x - x^2$. In like manner the equation

of the ellipse is $\frac{p}{a} \overline{a x - x^2} = y^2$,

of the hyperbola is $\frac{p}{a} . \overline{a x + x^2} = y^2$,

of the parobola is.................$p x = y^2$

Where a is an axis, and p the parameter. And in like manner for any other curves.

This method of expressing the nature of curves by algebraical equations was first introduced by Des Cartes, who, by thus connecting together the two sciences of algebra and geometry, made them mutually assisting to each other, and so laid the foundation of the greatest improvements that have been made in every branch of them since that time.

EQUATION *of time*, in astronomy and chronology, the reduction of the apparent time or motion of the sun to equable, mean, or true time. The difference between true and apparent time arises from two causes, the excentricity of the earth's orbit, and the obliquity of the ecliptic. See TIME, *equation of.*

EQUATOR, in geography, a great circle of the terrestrial globe, equidistant from its poles, and dividing it into two equal hemispheres; one north and the other south. It passes through the east and west points of the horizon, and at the meridian is raised as much above the horizon as is the complement of the latitude of the place. From this circle the latitude of places, whether north or south, begin to be reckoned in degrees of the meridian. All people living on this circle, called by geographers and navigators the line, have their days and nights constantly equal. It is in degrees of the equator that the longitude of places are reckoned; and as the natural day is measured by one revolution of the equator, it follows that one hour answers to $\frac{360}{24} = 15$ degrees: hence one degree of the equator will contain four minutes of time; 15 minutes of a degree will make a minute of an hour; and, consequently, four seconds answer to one minute of a degree.

EQUATIONAL. See OBSERVATORY.

EQUERRY, in the British customs, an officer of state, under the master of the horse. There are five equerries who ride abroad with his Majesty; for which purpose they give their attendance monthly, one at a time, and are allowed a table.

EQUISETUM, in botany, English *horsetail,* a genus of the Cryptogamia Filices class and order. Natural order of Filices or Ferns. There are seven species. They are natives of most parts of Europe, in woods and shady places.

EQUIANGULAR, in geometry, an epithet given to figures, whose angles are all equal; such are, a square, an equilateral triangle, &c.

EQUICRURAL, in geometry, the same with isosceles. See ISOSCELES TRIANGLE.

EQUIDIFFERENT *numbers*, in arithmetic, are of two kinds. 1. Continually equidifferent, is when, in a series of three numbers, there is the same difference between the first and second, as there is between the second and third; as 3, 6, 9. And 2. Discretely equidifferent, is when, in a series of four numbers or quantities, there is the same difference between the first and second as there is between the third and fourth: such are, 3, 6, 7, 10.

EQUIDISTANT, an appellation given to things placed at equal distance from some fixed point, or place, to which they are referred.

EQUILATERAL, in general, something that hath equal sides, as an equilateral angle.

EQUILATERAL *hyperbola,* one whose transverse diameter is equal to its parameter; and so all the other diameters equal to their parameters: in such an hyperbola, the asymptotes always cut one another at right angles in the centre. Its most simple equation, with regard to the transverse axis, is $y^2 = x - a^2$; and with regard to the conjugate, $y^2 = x^2 + a^2$, when a is the semitransverse, or semiconjugate. The length of the curve cannot be found by means of the quadrature of any space, of which a conic section is any part of the perimeter.

EQUILIBRIUM, in mechanics, is when the two ends of a lever or balance hang so exactly even and level, that neither doth ascend or descend, but keep in a position parallel to the horizon, which is occasioned by their being both charged with an equal weight.

EQUIMULTIPLES, in arithmetic and geometry, are numbers and quantities multiplied by one and the same number or quantity. Hence, equimultiples are

always in the same ratio to each other, as the simple quantities before multiplication: thus, if 6 and 8 are multiplied by 4, the equimultiples 24 and 32 will be to each other as 6 to 8.

EQUINOCTIAL, in astronomy, a great circle of the celestial globe, whose poles are the poles of the world. It is so called, because, whenever the sun comes to this circle, the days and nights are equal all over the globe; being the same with that which the sun seems to describe at the time of the two equinoxes of spring and autumn. All stars directly under this circle have no declination, and always rise due east, and set full west. The hour circles are drawn at right angles to it, passing through every fifteenth degree; and the parallels to it are called parallels of declination.

EQUINOX, the time when the sun enters either of the equinoctial points, where the ecliptic intersects the equinoctial. It was evidently an important problem in practical astronomy, to determine the exact moment of the sun's occupying these stations; for it was natural to compute the course of the year from that moment. Accordingly, this has been the leading problem in the astronomy of all nations. It it susceptible of considerable precision, without any apparatus of instruments. It is only necessary to observe the sun's declination on the noon of two or three days before and after the equinoctial day. On two consecutive days of this number, his declination must have changed from north to south, or from south to north. If his declination on one day was observed to be 21′ north, and on the next 5′ south, it follows that his declination was nothing, or that he was in the equinoctial point about 23 minutes after 7 in the morning of the second day. Knowing the precise moments, and knowing the rate of the sun's motion in the ecliptic, it is easy to ascertain the precise point of the ecliptic in which the equator intersected it. By a series of such observations made at Alexandria, between the years 161 and 127 before Christ, Hipparchus, the father of our astronomy, found that the point of the autumnal equinox was about six degrees to the eastward of the star called spica virginis. Eager to determine every thing by multiplied observations, he ransacked all the Chaldean, Egyptian, and other records to which his travels could procure him access, for observations of the same kind; but he does not mention his having found any. He found, however, some observations of Aristillus and Timochares, made about 150 years before. From these it appeared evident that the point of the autumnal equinox was then about eight degrees east of the same star. He discusses these observations with great sagacity and rigour; and, on their authority, he asserts that the equinoctial points are not fixed in the heavens, but move to the westward about a degree in 75 years, or somewhat less.

This motion is called the procession of the equinoxes, because by it the time and place of the sun's equinoctial station precedes the usual calculation: it is fully confirmed by all subsequent observations. In 1750, the autumnal equinox was observed to be 20° 21′ westward of spica virginis. Supposing the motion to have been uniform during this period of ages, it follows that the annual precession is about 50″ and one-third; that is, if the celestial equator cuts the ecliptic in a particular point on any day of this year, it will on the same day of the following year cut it in a point 50″ and one-third to the west of it, and the sun will come to the equinox 20′ 23″ before he has completed his round of the heavens. Thus the equinoctial, or tropical year, or true year of seasons, is so much shorter than the revolution of the sun, or the sidereal year. It is this discovery that has chiefly immortalized the name of Hipparchus, though it must be acknowledged that all his astronomical researches have been conducted with the same sagacity and intelligence. It was natural, therefore, for him to value himself highly for the discovery. It must be acknowledged to be one of the most singular that has been made, that the revolution of the whole heavens should not be stable, but its axis continually changing. For it must be observed, that since the equator changes its position, and the equator is only an imaginary circle, equidistant from the two poles, or extremities of the axis, these poles, and this axis, must equally change their positions. The equinoctial points make a complete revolution in about 25,745 years, the equator being all the while inclined to the ecliptic in nearly the same angle. Therefore the poles of this diurnal revolution must describe a circle round the poles of the ecliptic, at the distance of about 23½ degrees in 25,745 years; and in the time of Timochares, the north pole of the heavens must have been 30 degrees eastward of where it now is.

EQUITY.

EQUITY, *quasi æqualitas*, is generally understood, in law, a liberal correction, or qualification of the law, where it is too strict, too confined, or severe, and is sometimes applied, where, by the words of a statute, a case does not fall within it, yet being within the mischief, the judges, by an equitable construction, have extended its application to that case. Equity is understood as a correction of the law: the difference between courts of equity and law is known only in this country, and arises principally, if not entirely, from the different modes of trial, which must ever render them essentially distinct. For it is obvious, that where men form contracts in the ordinary course of law, the legal consequence, and the enforcement of them, must be, according to general rules, applicable to general cases; and the nature of our mode of trial by jury is so strict in the evidence which it requires, that a strict legal decision alone can justly be founded upon it. There are, however, many cases, in which there are particular circumstances between the different parties peculiar to their case, which give rise to exceptions and equitable decisions wholly different from the general rule. These cases of exception are such, that unless the judge can inquire into all the circumstances affecting the conscience of the several parties, a perfectly equitable decision cannot be given. For this purpose the court of equity is empowered to examine all the litigant parties upon their oaths, and to make every one answer to the full, as to all the circumstances affecting the case, which is not done in a court of law, where no person can be a witness in his own cause.

In equity, however, the plaintiff by filing his bill waves the objections, and submits to take the answer of each defendant, though he cannot be admitted to give evidence himself. This is the process by what is called English bill in equity; and the form of proceeding, though somewhat tardy, gives the parties the fullest opportunity of obtaining a final decision according to good conscience. It is this difference in the proceeding, which has rendered the best judges in courts of law averse to introducing equitable distinctions and principles, applicable to courts of equity, in courts of law, because they have not the same means of informing their consciences upon all the circumstances necessary to induce them to alter the strict law according to the peculiar facts, or conscientious circumstances of the case. Formerly, it is supposed, the King, upon petition, referred the case upon a harsh decision at law to a committee, together with the Chancellor; but in the time of Edward III. when uses, or trusts of lands, which were discountenanced at common law, were considered as binding in conscience by the clergy, John Waltham, Chancellor to Richard II. introduced the writ of *subpæna*, returnable in the Court of Chancery only, to make the tenant, or feoffee to uses, answerable for the confidence reposed in him, and this writ is the commencement of a suit in equity, which has been chiefly modelled by Lord Ellesmere, the great Lord Bacon, and Sir Heneage Finch, in the time of Charles I. Lord Hardwicke followed, at some distance, after these great men, and by his decisions, together with those of his successors, has established a practical system of equity, which is as definite and well understood as the law itself; and taking into consideration the leading circumstances above mentioned, is nothing more than the law administered according to the justice of the case. There are some cases which belong more peculiarly to a court of chancery, as the care of infants, and appointing guardians to them; so of lunatics and charities, in which the Chancellor acts for the King as keeper of his conscience. In other cases, as in cases of trust, matters of fraud, account, suits for a discovery, matters of accident, and the like, courts of equity act, in aid of the courts of law, and give relief, where, from the nature of the case, a court of law cannot relieve. Thus, where an agreement is to be performed, courts of law can only give damages for the breach; but a court of equity, taking all the circumstances into consideration, directs and enjoins a specific performance of it according to good conscience. So, where it apprehends an injury likely to be done, it will interfere to prevent it.

We have thought this explanation of the general principles, which distinguish courts of law and equity, better suited to a work like the present, than an attempt to abridge any more particular account of the practice and principles of courts of equity, which will be found to proceed upon the ordinary rules of good conscience, as far as they can be reduced to practice. An appeal lies from the Chancellor to the House of Lords. The Court of Exchequer has a court of equi-

ty, and so have most courts of peculiar jurisdiction.

Equity, *of redemption.* Upon a mortgage, although the estate upon non-payment of the money becomes vested in the mortgagee, yet equity considers it only a pledge for the money, and gives the party a right to redeem, which is called his equity of redemption. If the mortgagee is desirous to bar the equity of redemption, he may oblige the mortgager either to pay the money, or be foreclosed of his equity, which is done by proceedings in the Court of Chancery by bill of foreclosure.

EQUUS, *the horse*, in natural history, a genus of mammalia of the order of Belluæ. Generic character: upper fore-teeth parallel, and six in number; in the lower jaw six, rather more projecting; tusks on each side, in both jaws, remote from the rest; feet with undivided hoofs. There are six species, and very many varieties.

E. caballus, or the common horse. The elegance, grace, and usefulness of the horse entitle him to particular attention, and certainly confer upon him a pre-eminence above all other quadrupeds. There are few parts of the world in which horses are not to be found; and in various parts of Africa they maintain their original independence, and range at pleasure in herds of several hundreds, having always one or more as an advanced guard, to alarm against approaching danger. These alarms are expressed by a sudden snorting, at which the main body gallop off with the most surprising swiftness. In the south of Siberia also, and at the north-west of China, wild horses are to be found in considerable abundance; and it is stated, that different herds will carry on hostilities, and one party frequently surround an enemy inferior in number, and conduct them to the hostile territory, manœuvring perpetually to baffle all their attempts to escape. On each bank of the river Don, towards the Palus Mœotis, horses are found wild, but are supposed to be the descendants of domesticated horses, belonging to the Russian army occupied in the siege of Asoph, at the close of the seventeenth century. In America, likewise, horses are found wild in vast abundance, sweeping the extensive plains of Buenos Ayres, and the Brazils particularly, in immense herds. They are taken by the inhabitants, by throwing, with great dexterity, a noosed cord over their heads, at full speed; and are often destroyed merely for their hides, as an article of commerce. These American horses are the descendants of those which were introduced by the Spaniards on their discovery of America, as none previously existed on that continent. They are, in general, small and clumsily formed, and their height is rarely above fourteen hands. In the deserts of Arabia, it has been stated by several writers, wild horses are extremely abundant; but Shaw and Sonnini, with greater probability, confine their appearance in that country to the borders of the desert, the latter not supplying materials for their subsistence. Mr. Bruce mentions the horses of Nubia as unequalled in beauty, and far superior to those of Arabia. Of the former little notice has been taken but from that observant traveller; of the latter the fame has long been distinguished; and the Arabian horse, celebrated for his beauty and swiftness, has been long exported to the most remote countries of Europe, to correct and improve the native breeds. In Arabia, almost every man possesses his horse, which lives in the same apartment, or tent, with his family, and is considered as constituting by no means the lest important part of it. Harsh and violent applications, such as the whip or spur, are rarely inflicted on it. It is fed with the most regular attention, and cleaned with incessant assiduity. The Arab occasionally appears to carry on a conversational intercourse with his horse, and his external attachment to this animal excites in return a corresponding affection. The horse being purified under his management from every vicious propensity, and guarded against casual injury with the utmost solicitude, suffering the infant children to climb its legs without the slightest attempt to kick or shake them off. The Arabs never cross the breeds of horses, and preserve the genealogies of these animals for a considerable number of generations. The horses of Barbary are in high reputation, also, for speed and elegance, as are likewise those of Spain. In various parts of the East, as in India and in some parts of China, there exists a race of these animals, scarcely exceeding the height of a large mastiff, and with their diminutive size are generally connected not a little intractability and mischievousness. In no country of the globe has the breeding of the horse been attended to on more enlarged and philosophic principles than in Great Britain; and with such success have the efforts of the English on this subject been at-

tended, that their horses are in the highest estimation throughout Europe, and in periods of national tranquillity constitute an important article of exportation. Their race-horse is not excelled in fleetness or beauty by the coursers of Barbary or Arabia, and in supporting a continuance of intense effort is far superior to them both. Details of the exploits of English racers form a subject of extreme interest to a particular description of readers, and cannot be considered by any admirers of nature as beneath attention. Out of innumerable instances which have been authenticated, we shall just mention, that Bay Malton, belonging to the Marquis of Rockingham, ran four miles on the York course in seven minutes and forty-four seconds. The celebrated Childers is supposed to have been the fleetest horse ever known in the world. He was opposed by all the most distinguished horses of his day, and what is, perhaps, unprecedented in such a variety of contests, in every instance bore off the prize. He is stated to have run a mile in very little more than a minute, and his general progress on a four mile course was at the rate of eighty-two feet and a half in a second. Eclipse was almost equally swift with Childers, and was considerably stronger. His form was by no means considered as handsome, as indeed his dimensions deviated very considerably from those which were supposed to constitute the standard of perfect beauty in the horse; but, on the most minute examination, his structure was found to be contrived with the most exquisite mechanism for speed. This horse died at the age of twenty-six years, which, though unquestionably great, has been often considerably exceeded. Matchem, another celebrated racer, died at the age of thirty-two. For the race-horse, see Mammalia, Plate XI. fig. 1.

The hunter is another distinct class of horses in England, where it is brought, by minute attention to breeding, to a high degree of excellence. With a considerable portion of the speed of the race-horse, it combines inexpressibly more strength; and the exertions which it often endures and survives, in violent chases of several hours continuance, are a decided proof of its vigour and value.

The draught-horse constitutes another class of these most interesting animals, and is no where advanced to such size and power as in Great Britain. Yorkshire and Lincolnshire are the most celebrated counties for this breed, whence several have been brought to London, which have each, for a short distance, drawn, without difficulty, the weight of three tons, half of which is considered as the regular draught. A horse of this class was exhibited as a curiosity in London in the year 1805, no less than twenty hands in height. For the cart-horse, see Mammalia, Plate XI. fig. 2.

The colour of the horse is generally considered as a matter of trifling consequence. A bright or shining bay appears in this country to obtain the preference. In China, what are called pie-bald horses are in particular estimation. On occasions of particular state in England, eight horses of a cream colour draw the royal carriage. The ancients appear to have connected their ideas of pomp and dignity on similar occasions with the perfect white, in allusion to which the classics furnish an infinity of circumstances. Absolute whiteness in the horse is, in this country, in almost every instance, the effect of age, which expunges the dark spots of the original grey. The improvement of the horse has within a few years been an object of the attention of government, as well as of enlightened individuals; and establishments have been formed on a liberal scale for the promotion of veterinary science. In France the government has recently devoted considerable attention to this highly important subject; and during the last year only (1807) a very considerable number of veterinary schools or colleges were instituted in the capital, and the principal cities of the departments.

E. asinus, the ass. A warm climate is favourable to this species, (as also indeed to the horse,) which is found in various parts of Africa in a state of nature, in which it is gregarious, and displays very considerable beauty, and even sprightliness. In the mountainous territories of Tartary, and in the south of India and Persia, asses occur in great abundance, and are said to be here either absolutely white, or of a pale grey. Their hair also is reported to be bright and silky. In Persia asses are extremely in use, and supply, for different purposes, two very different races, one heavy and slow, and the other slight, sprightly, and agile, which last is exclusively kept for the saddle. The practice is prevalent in that country, of slitting the nostrils of these animals, by which it is imagined they breathe with greater freedom, and can consequently sustain greater exertion. The ass is stated to have been un-

known in England before the reign of Elizabeth. It is now, however, completely naturalized, and its services to the poor, and consequently to the rich, are of distinguished and almost indispensable importance. With respect to food, a little is sufficient for its wants, and the most coarse and neglected herbage supplies it with an acceptable repast. The plantain is its most favourite herbage. In the choice of water it is, however, extremely fastidious, drinking only of that which is perfectly pure and clear. It is one of the most patient and persevering of animals, but in connection with these qualities, it possesses also great sluggishness, and often obstinacy. Owing to the extreme thickness of its skin, it possesses little sensibility to the application of the whip or the stings of insects, and the want of moisture, united to the above circumstance, precludes it more effectually than, perhaps, any other quadruped, from the annoyance of vermin. The ass is remarkable for particular caution against wetting its feet, to avoid which it will make various turns and crossings on the road. It seldom lies down to sleep, unless it is particularly fatigued, and sleeps considerably less than the horse. It is capable of being taught a variety of exercises, and, though regarded as a just emblem of stupidity, is far more susceptible and docile than is generally imagined, though unquestionably far inferior to the horse in these respects. Its bray is harsh and disgusting, particularly that of the male. The female has been considered by many naturalists as incapable of braying, contrary, in this country, most certainly, to the most frequent and obvious facts. Her voice is somewhat shriller and weaker than the male. In several countries of Africa, and in some islands of the Archipelago, asses are hunted for food, and their flesh is regarded as highly nutritious and agreeable. In England their milk is in high esteem in cases of debility and decline, and where the stomach of the patient is incapable of digesting the more strong and oily produce of the cow. In America, the ass was introduced by the Spaniards, and on the southern continent of that quarter of the world these animals are found at present in vast herds, having multiplied to an extreme degree, and being frequently hunted by the natives, who contrive to surround a particular herd, and enclosing them gradually within a very small compass, entangle as many as they chuse to take, by throwing over each a noosed cord with unfailing dexterity. The animal is then fettered with extreme ease, and left in that state upon the ground till the conclusion of the chase, which sometimes is continued for two or three days. They are as swift as horses, and indeed, in all ages, the wild ass has been considered as distinguished by rapidity. They attack and defend both with the hoof and teeth, in the same manner as horses. The slowness and sluggishness of the ass have frequently excited ludicrous feelings, and it is related of Crassus, that the only occasion on which he was ever known to laugh was at an ass eating thistles. The habits of the ass, however, do not appear certainly a more fertile subject of ridicule than those of that philosophnr.

The mule is a hybrid animal, between the horse and the ass, and from its barrenness affords unquestionable evidence of the distinctness of these two species. In mountainous districts the mule is extremely serviceable as a beast of burthen, as it moves over steep and rugged roads with astonishing firmness, steadiness, and facility. In England these animals are but little used, and where they are employed, it is almost uniformly in the above situations. The breed in this country has been considerably improved within a short period, by the importation of asses from Spain, where mules are in the highest estimation, and employed by the first orders of the opulent and noble, both for the saddle and the carriage. They are not unfrequently sold in that kingdom at the price of sixty or seventy guineas. To those who reside in a country abounding with precipitous passes and rugged roads, mules are invaluable, on account of their steadiness and accuracy of step. In the Alps they are uniformly employed by travellers to descend roads, the narrowness, obliquity, and danger of which fill the rider with something approaching to consternation.

Their manner, on particular occasions of perilous and steep descent, is worthy of being mentioned. Among the Alps the path often occupies only the space of a few feet in width, having on one side an eminence of perpendicular ascent, and on the other a vast abyss, and, as it generally follows the direction of the mountains, presents frequently declivities of several hundred yards. On arriving at one of these, the mule for a moment halts, and no effort of the rider can for the time urge it forward. It appears

alarmed at the contemplation of the danger. In a few moments, however, it places its fore feet as it might be supposed to do in the act of stopping itself, and almost immediately closes its hinder feet, somewhat advancing them, so as to give the idea of its intention to lie down. In this attitude it glides down the descent with astonishing rapidity, yet, amidst all its speed, retains that self government, which enables it to follow, with the most perfect precision, all the windings of the road, and to avoid every impediment to its progress and security. During these singular and critical movements, the rider must be cautious to avoid the slightest check, and must devote his attention to the preservation of his seat, without deranging the equilibrium of the mule, the least disordering of which would be inevitably fatal. By long experience on these perilous roads, some mules have acquired the most admirable and astonishing dexterity, and having been in particular requisition from their extraordinary skill and fame, have become a source of corresponding profit to their owners. See Mammalia, Plate XI. fig. 3.

E. zebra, or the zebra, is somewhat larger than the ass, and far more elegant in its form, particularly with respect to the head and ears. It is either of a milk white or cream colour, adorned on every part with brownish-black stripes, running transversely on the limbs and body, and longitudinally on the face, and arranged with exquisite order, and attended with extreme brilliancy and beauty. These animals inhabit in Africa from Ethiopia to the Cape of Good Hope, between which they exist in vast herds, possessing much of the habits of the wild horse and ass. Like them, they are extremely vigilant, and extremely fleet, and so fearful of the sight of man, that, on his first appearance, they fly off with all possible rapidity. They are of an untractable temper, and the attempts which have been made to domesticate them have in no instance been attended with complete success. Even when taken young, and brought up with particulalar assiduity, they have yet exhibited a disposition so wild and vicious, as to give little hope that this beautiful race of creatures will ever eventually be of great service to mankind. Our slight acquaintance, however, with them, would render a positive decision to this purpose exceedingly premature. Should the zebra ever be made safely and easily convertible to the same purposes as the horse, an elegant variety would be added to the luxuries of the great and opulent. See Mammalia, Plate XI. fig. 4.

E. quagga, is marked with fewer stripes than the zebra, and those few of a browner colour and larger size. The hinder parts of this animal are not striped, but spotted. It is found in Africa, is gregarious, extremely fleet, and more tractable than the last species, so much so indeed, that by the Dutch settlers at the Cape it has been occasionally employed for the purposes both of draught and saddle. The same parts of Africa abound both in the quagga and the zebra, but the two species are never seen together.

E. bisulcus, or the huemel, is a native of South America, particularly of the rugged districts of the Andes. It resembles the ass in general form, and the horse in voice, and in the smallness and neatness of its ears; it is distinguished from both, and from every other known species of the equine genus, by having a divided hoof, and constitutes a link between the cloven-hoofed and whole-hoofed quadrupeds.

ERECTOR. See Anatomy.

ERICA, in botany, *heath*, a genus of the Octandria Monogynia class and order. Natural order of Bicornes. Ericæ, Jussieu. Essential character: calyx four-leaved; corolla four-cleft; filaments inserted into the receptacle; anthers cloven; capsule four-celled. There are eighty-four species. These are small shrubs. Their leaves are linear, lanceolate, or ovate, imbricate or remote, entire, ciliate or serrate, in some opposite, in most whorled, in others again scattered; bractes usually three; the flowers are either axillary or terminating, and variously disposed; corolla mostly of a purple colour; anthers usually oblong, though sometimes linear; germ in most species smooth.

ERIDANUS, in astronomy, a constellation of the southern hemisphere; containing, according to different authors, 19, 30, or even 68 stars.

ERIGERON, in botany, a genus of the Syngenesia Polygamia Superflua class and order. Natural order of Compositæ Discoideæ. Corymbiferæ, Jussieu. Essential character: receptacle naked; down hairy; corolla of the ray linear, and very narrow. There are thirty species. The Erigeron pulchellum, an American species, is said to be one of the

Indian remedies for the bite of the rattle-snake.

ERINACEUS, the *hedge-hog*, in natural history, a genus of Mammalia, of the order Feræ. Generic character: two fore teeth, both above and below, those of the upper jaw distant, those of the lower approximated; five tusks an each side of the upper jaw, three on each side of the lower; four grinders on each side, both above and below; body covered on the upper part with spines. There are six species.

E. Europæus, the common hedge-hog, is found in all the temperate climates of Europe and Asia. Its whole length is about eleven inches, its colour generally a grey brown. It lives in hedges and thickets, and subsists on young toads, worms, beetles, crabs, fruits, and birds. It conceals itself in its hole during the day, and by night wanders in search of food. It builds its nest of moss, and produces four or five young ones at a birth. These animals possess the curious, though not completely singular, property of rolling themselves into a compact form, like a ball, their spines only appearing, and presenting to the enemy an armed front, which he generally trembles to assail. The greater the danger it is exposed to, the more closely it is compacted, and it is difficult to compel it from this state to its usual form without the application of cold water, on being immersed in which it appears in its usual shape. It lies in this ball-like form during the winter in its mossy nest, insensible to the extremity of the cold, and, on the approach of spring, resumes its nocturnal researches. It is perfectly harmless, and in some countries is said to be domesticated, and in this state is employed by the Calmucks in their habitations to clear them from various annoying insects. It possesses a considerable odour of musk. It is occasionally hunted by dogs, which, however, before they are disciplined to the pursuit, are not fond of encountering these animals, being deterred by their horrid aspect, or wounding bristles. They soon, however, find their superiority, and after a little irritation from the spines of the animal, are exasperated to the full application of their teeth, which the hedge-hog is totally unable to resist. Finding his globular form now cease to be his effectual security, he unrolls himself, and falls an immediate victim to the dogs, who are generally urged on to the sport by persons of far greater curiosity than sensibility. See Mammalia, Plate XII. fig. 1.

E. Mallaccensis, or the Malacca hedge-hog, is about the size of the common porcupine; its ears are long and pendulous, and its spines, or rather quills, are stated to vary on different parts of the animal, from the length of an inch to a foot and a half. It is remarkable for a concretion in the gall-bladder about the size of a walnut, which is intensely bitter, and which, in the days of medical ignorance and superstition, was imagined to possess the highest virtue in cases of fever and other malignant diesases, and, when found entire, has been sold occasionally for more than two hundred pounds. These bezoars, however, are by no means peculiar to this animal. See Mammalia, Plate XII. fig. 2.

ERINUS, in botany, a genus of the Didynamia Angiospermia class and order. Natural order of Personatæ. Pediculares, Jussieu. Essential character: calyx five-leaved; corolla border five-cleft, equal, with the lobes emarginate; upper lip very short, reflex; capsule two-celled. There are thirteen species. The flowers in this genus are either axillary, or with one bracte to each, in a terminating spike; leaves alternate. They are chiefly natives of Africa.

ERIOCAULON, a genus of the Triandria Tryginia class and order. Natural order of Ensatæ. Junci, Jussieu. Essential character: calyx common, an imbricate head; petals three, equal; stamina upon the germ. There are six species.

ERIOCEPHALUS, in botany, a genus of the Syngenesia Polygamia Necessaria class and order. Natural order of Compositæ Nucamentaceæ. Corymbiferæ, Jussieu. Essential character: receptacle subvillose; down none; calyx ten leaved, equal; in the ray five floscules. There are two species, *viz.* E. africanus, cluster-leaved eriocephalus, and E. racemosus, silvery-leaved eriocephalus. Both natives of the Cape of Good Hope.

The leaves of the first mentioned are woolly; they come out in clusters, some taper and entire, others divided into three pairs, which spread open like a hand; they have a strong smell when bruised, approaching to that of lavender cotton, though not so rank. The flowers are produced in small clusters at the ends of the branches, standing erect. The female florets which compose the ray form a hollow, in the middle of which the hermaphrodite florets forming the disk are situated.

ERIOPHORUM, in botany, *cotton grass*, a genus of the Triandria Monogynia class

and order. Natural order of Calamaria. Cyperoideæ, Jussieu. Essential character: glumes chaffy, imbricate every way; corolla none; seed one, surrounded with a very long wool. There are six species. These are bog plants, and are nearly allied to the grasses; they are rarely cultivated in gardens.

ERIOSPERMUM, in botany, a genus of the Hexandria Monogynia class and order. Corolla six-petalled, campanulate, permanent; filaments dilated at the base; capsule three-celled; seeds invested with wool. There are three species.

ERIOSTEMUM, in botany, a genus of the Decandria Monogynia class and order. Calyx five parted; petals five, sessile; stamina flat, ciliate; antheræ pedicelled terminal; style from the base of the germ; capsules five, united, seated on a nectary covered with protuberances; seeds coated. One species, *viz.* E. australasia.

ERITHALIS, in botany, a genus of the Pentandria Monogynia class and order. Natural order of Rubiaceæ, Jussieu. Essential character: corolla five-parted, with the divisions bent back; calyx pitcher-shaped; berry ten-celled, inferior. There are two species, *viz.* the fruticosa and polygama.

ERMIN. See MUSTELA.

ERMIN, in heraldry, is always argent and sable, that is, a white field, or fur, with black spots. These spots are not of any determinate number, but may be more or less, at the pleasure of the painter, as the skins are thought not to be naturally so spotted; but serving for lining the garments of great persons, the furriers were wont, in order to add to their beauty, to sow bits of the black tails of the creatures that produced them upon the white of their skin, to render them the more conspicuous, which alteration was introduced into armoury.

ERMINE', or cross erminé, is one composed of four ermin spots. It is to be observed, that the colours in these arms are not to be expressed, because neither this cross nor these arms can be of any other colour but white and black.

ERNODEA, in botany, a genus of the Tetrandria Monogynia class and order. Essential character: calyx four-parted; corolla one-petalled, salver-shaped; berry two-celled; seeds solitary. There is but one species, *viz.* E. littoralis, a native of Jamaica.

ERODIUM, in botany, *cranes-bill*, a genus of the Monadelphia Pentandria class and order. Natural order of Gruinales. Gerania, Jussieu. Calyx five-leaved; corolla five-petalled; nectary five-scales, alternate with the filaments and glands at the base of the stamens; fruit five-grained, with a spiral beak, bearded on the inside. There are twenty-eight species.

ERODIUS, in natural history, a genus of insects of the order Coleoptera. Antennæ moniliform; feelers four, filiform; body roundish, gibbous, immarginate; thorax transverse; shells closely united, longer than the abdomen; jaw horny, bifid; lip horny, emarginate. There are four species.

EROTEUM, in botany, a genus of the Polyandria Monogynia class and order. Essential character: calyx five-leaved; corolla five-petalled; stile trifid; berry juiceless, three-celled, many-seeded. There are two species, *viz.* E. thœides, and E. undulatum, both natives of Jamaica.

ERROR, in law, signifies an error in pleading, or in the process on the judgment; and the writ which is brought for remedy of it is called a writ of error. This is a commission to judges of a superior court, by which they are authorized to examine the record upon which a judgment was given in an inferior court, and, on such examination, to affirm or reverse the same according to law. For particulars as to the practice of writs of error, see Tomlin's "Law Dictionary."

ERUCTATIONS, in medicine, are the effect of flatulent foods, and the crudities thence arising.

ERUDITION, denotes an extensive acquaintance with books, especially such as treat of the belles-lettres.

ERUPTION. See MEDICINE.

ERVUM, in botany, a genus of the Diadelphia Decandria class and order. Natural order of Papilionaceæ, or Leguminosæ. Essential character: calyx five-parted, the length of the corolla. There are six species; of which E. lens, flat-seeded tare, or common lentil, is an annual plant, and the least of the pulse kind which is cultivated; it rises with weak stalks a foot and half high, having pinnate leaves at each joint, composed of several pairs of narrow leaflets, terminated by a tendril, which supports it by fastening about some other plant; the flowers come out on short peduncles from the sides of the branches; they are small, of a pale purple colour, and three or four together; legumes short and flat, containing two or three flat, round seeds,

a little convex in the middle; the flowers appear in May; the seeds ripen in July.

ERYNGIUM, in botany, English *eryngo,* a genus of the Pentandria Digynia class and order. Natural order of Umbellatæ. Essential character: flowers in a head; receptacle chaffy. There are eleven species; these bear some resemblance to the thistles; the leaves are frequently spinous, as are also the involucres; the umbellets in some are inclosed in an involucre, which is often irregular and branched; in others they are dispersed.

ERYSIMUM, in botany, *hedge-mustard,* a genus of the Tetradynamia Siliquosa class and order. Natural order of Siliquosæ. Cruciferæ, Jussieu. Essential character: silique columnar, with four equal sides; calyx closed. There are eight species.

ERYSIPELAS. See MEDICINE.

ERYTHRINA, in botany, a genus of the Diadelphia Decandria class and order. Natural order of Papilionaceæ or Leguminosæ. Essential character: calyx two-lobed; corolla standard very long, lanceolate. There are seven species; these are small, prickly trees, or shrubs; leaves as in dolichos, ternate, stipulaceous; the petiolules jointed and awned, or glandular, seldom simple; flowers in fascicles from the axils, or in spikes at the ends of the stem and branches, generally scarlet.

ERYTHRONIUM, in botany, *dog-tooth violet,* a genus of the Hexandria Monogynia class and order. Natural order of Sarmentaceæ. Lilia, Jussieu. Essential charater: corolla six-petalled, bell-shaped; nectary tubercles two, fastened to the base of the alternate petals. There is but one species, with several varieties, *viz.* E. dens canis, dog-tooth-violet; the roots of this plant are white, oblong and fleshy, shaped like a tooth, whence its name.

ERYTHROXYLON, in botany, a genus of the Decandria Trigynia class and order. Natural order of Malpighiæ, Jussieu. Essential character: calyx turbinate; corolla having a small emarginate nectareous scale at the base of the petals; stamina connected at the base; drupe one-celled. There are five species.

ESCALLONIA, in botany, so named in honour of M. Escallon, a genus of the Pentandria Monogynia class and order. Natural order of Calycanthemæ. Onagræ, Jussieu. Essential character: calyx surrounding the fruit; stigma capitate; berry two-celled, containing many seeds. There are two species, *viz.* E. myrtylloides, and E. serrata.

ESCAPE, in law, is where one who is arrested gains his liberty before he is delivered by course of law. Escapes are either in civil or criminal cases; and in both respects may be distinguished into voluntary and negligent; voluntary, where it is with the consent of the keeper; negligent, where it is for want of due care in him. In civil cases, after the prisoner has been suffered voluntarily to escape, the sheriff can never retake him, but must answer for the debt; but the plaintiff may retake him at any time. In the case of a negligent escape, the sheriff, upon fresh pursuit, may retake the prisoner; and the sheriff shall be excused, if he has him again before any action brought against himself for the escape. When a defendant is once in custody in execution, upon a *capias ad satisfaciendum,* he is to be kept in close and safe custody; and if he be afterwards seen at large, it is an escape, and the plaintiff may have an action for his whole debt against the sheriff; for, though upon arrests, and what is called mesne process, being such as intervenes between the commencement and end of a suit, the sheriff, till the statute 8 and 9 Will. c. 27. might have indulged the defendant as he pleased, so as he produced him in court to answer the plaintiff at the return of the writ; yet, upon a taking in execution, he could never give any indulgence; for in that case confinement is the whole of the debtor's punishment, and of the satisfaction made to the creditor. A rescue of a prisoner in execution, either in going to gaol, or in gaol, or a breach of prison, will not excuse the sheriff from being guilty of, and answering for, the escape; for he ought to have sufficient force to keep him, seeing he may command the power of the county. In criminal cases, an escape of a person arrested, by eluding the vigilance of his keeper before he is put in hold, is an offence against public justice, and the party himself is punishable by fine and imprisonment; but voluntary escapes amount to the same kind of offence, and are punishable in the same degree as the offence of which the prisoner is guilty, and for which he is in custody, whether treason, felony, or trespass, and this whether he was actually committed to gaol, or only under a bare arrest; but the officer cannot be thus punished, till the original delinquent is actually found guilty, or convicted by ver-

dict, confession, or outlawry; otherwise it might happen, that the officer should be punished for treason or felony, and the party escaping turn out to be an innocent man. But, before the conviction of the principal party, the officer thus neglecting his duty may be fined and imprisoned for a misdemeanor. 4 Black. 129.

If any person shall convey, or cause to be conveyed, into any gaol, any disguise, instrument, or arms, proper to facilitate the escape of prisoners attainted or convicted of treason or felony, although no escape or attempt to escape be made, such person so offending, and convicted, shall be deemed guilty of felony, and be transported for seven years. 16 Geo. II. c. 31.

ESCAPEMENT. See SCAPEMENT.

ESCHALOT. See ALLIUM

ESCHEAT, in our law, denotes an obstruction of the course of descent, and a consequent determination of the tenure, by some unforeseen contingency; in which case, the land naturally results back, by a kind of reversion, to the original grantor or lord of the fee. This happens, either for want of heirs of the person last seized, or by his attainder for a crime by him committed; in which latter case, the blood is tainted, stained, or corrupted, and the inheritable quality of it is thereby extinguished.

ESCHEAT, for want of heirs, is where the tenant dies without any relations on the part of any of his ancestors, or where he dies without any relations of those ancestors, paternal or maternal, from whom his estate descended; or where he dies without any relations of the whole blood. Bastards are also incapable of inheritance; and therefore, if there be no other claimant than such illegitimate children, the land shall escheat to the lord; and as bastards cannot be heirs to themselves, so neither can they have any heirs but those of their own bodies; and therefore, if a bastard purchase lands, and die seized, without issue and intestate, the land shall escheat to the lord of the fee. Aliens, also, that is, persons born out of the King's allegiance, are incapable of taking by descent; and, unless naturalized, are also incapable of taking by purchase; and therefore, if there be no natural born subjects to claim, such lands shall in like manner escheat. By attainder for treason or other felony, the blood of the person attainted is corrupted and stained, and the original donation of the feud is thereby determined, it being always granted to the vassal on the implied condition of his well demeaning himself. In consequence of which corruption and extinction of hereditary blood, the land of all felons would immediately revert in the lord, but that the superior law of forfeiture intervenes, and intercepts it in its passage; in case of treason, for ever; in case of other felony, for only a year and a day; after which time it goes to the lord in a regular course of escheat. 2 Black. c. 15.

ESCHEATOR was an ancient officer, so called, because his office was properly to look to escheats, wardships, and other casualties, belonging to the crown. This office, having its chief dependance on the courts of wards, is now out of date.

ESCUAGE, signifies a kind of knights' service, called service of the shield, whereby the tenant is bound to follow his lord into the Scotch or Welsh wars, at his own expence. He who held a whole knights' fee was bound to serve with horse and arms 40 days at his own charge, and he who held half a knights' fee was to serve 20 days.

ESCUTCHEON, in heraldry, is derived from the French *escussion*, and that from the Latin *scutum*, and signifies the shield whereon coats of arms are represented. Most nations, of the remotest antiquity, were wont to have their shields distinguished by certain marks painted on them; and to have such on their shields was a token of honour, none being permitted to have them till they had performed some honourable action. The escutcheon, as used at present, is square, only rounded off at the bottom. As to the bearings on shields, they might at first be arbitrary, according to the fancy of the bearer; but, in process of time, they came to be the gift of kings and generals, as the reward of honourable actions.

ESCUTCHEON *of pretence*, that on which a man carries his wife's coat of arms, being an heiress, and having issue by her. It is placed over the coat of the husband, who thereby shews forth his pretensions to her lands.

ESOX, the *pike*, in natural history, a genus of fishes of the order Abdominales. Generic character: head flattish above, mouth and throat large; teeth sharp, in the jaws, palate, and tongue; nostrils double, near the eyes; gill-membrane with from seven to twelve rays; body elongated; dorsal fin near the tail. Gme-

lin enumerates fifteen species, and Shaw twenty-two; we shall notice the following, as the most important.

E. lucius, or the common pike. In Lapland this fish, we are informed, is found not unfrequently of the length of eight feet. It is to be met with in most lakes and small rivers throughout Europe. Its common colour is a pale olive, but in Holland it has been seen of an orange colour, with black spots. When in its perfect state its colours are uniformly found to be most vivid. The largest pike ever caught in Great Britain is supposed to have been one which weighed thirty-five pounds. It is a fish of particularly rapid growth, and also of great longevity, having been ascertained, according to one of the natural historians of Poland, to live to the age of ninety years. The stomach of the pike is particularly strong, muscular, and extended. Its teeth without including those nearest the throat, are no fewer than seven hundred, and those which are placed on the jaws are alternately moveable and fixed. It is one of the most voracious of fishes, and is often found to swallow water rats and young ducks: it has even attacked the swan, and swallowed the head and great part of the neck of that bird: but being unable to separate these from the body, it became, in this instance, the victim of its voracity. It will engage with the otter in the most ferocious and persevering contests for any article of food, and after long abstinence has been known to seize on the lips of a mule, and to be drawn up by the affrighted quadruped before it could possess time for extrication. It is not unfrequently caught in the latter end of spring in the ditches near the Thames, while asleep, by means of a noosed chord dexterously slipped round it. The appearance of the pike is dreaded by the smaller fishes, as the signal of destruction, and is observed to excite in them all the indications of detestation and terror.

E. stomias, or the piper-mouthed pike, is a native of the Mediterranean sea, about eighteen inches in length, and of a greenish brown colour. Its lower jaw is considerably longer than the upper; it has two fore teeth in the upper, and these, with two of the under, project from the mouth when shut; the first ray of the dorsal fin, which is near the head, is very long and cetaceous, and its body gradually tapers towards the tail, which is somewhat forked. It is a very curious fish, and a specimen of it is to be seen in the British Museum.

ESPALIERS, in gardening, are rows of trees planted about a whole garden or plantation, or in hedges, so as to inclose quarters or separate parts of a garden; and are trained up regularly to a lattice of woodwork in a close hedge, for the defence of tender plants against the injuries of wind and weather. They are of admirable use and beauty in a kitchen-garden, serving not only to shelter the tender plants, but screen them from the sight of persons in the walks. See GARDENING.

ESPLANADE, in fortification, is the sloping of the parapet of the covered way towards the champaign. It is the same with glacis, and is more properly the empty space between the citadel and the houses of a town.

ESQUIRE, was anciently the person that attended a knight in the time of war, and carried his shield. This title has not for a long time had any relation to the office of the person, as to carry arms, &c. Those to whom the title of esquire is now of right due, are all noblemen's younger sons, and the eldest sons of such younger sons: the eldest sons of knights, and their eldest sons: the officers of the King's courts, and of his household: counsellors at law, justices of the peace, &c. though those latter are only esquires in reputation: besides, a justice of the peace holds this title no longer than he is in commission, in case he is not otherwise qualified to bear it; but a sheriff of a county, who is a superior officer, retains the title of a squire during life, in consequence of the trust once reposed in him: the heads of some ancient families are said to be esquires by prescription.

ESQUIRE, is a name of dignity, next above the common title of gentleman and below a knight; heretofore it signified one that was attendant, and had his employment as a servant, waiting on such as had the order of knighthood, bearing their shields, and helping him to horse, and the like. All Irish and foreign peers are only esquires in English law, and must be so named in all legal proceedings. Esquires of the King, are such who have the title by creation; these, when they are created, have a collar of SS put about their necks, and a pair of silver spurs is bestowed on them; and they were wont to bear before the prince in war, a shield or lance. There are four esquires of the King's body, to attend on his majesty's person.

ESSAY, in metallurgy. See Assaying.

ESSENCE, in chemistry, denotes the purest, most subtile, and balsamic part of a body; extracted either by simple expression, or by means of fire, from fruits, flowers, and the like. Of these there are a great variety used, on account of their agreeable smell and taste, by apothecaries, perfumers, and others. Those extracted by means of fire, with more propriety, are to be counted among the essential oils.

Essence *of bergamot*, is a fragrant essence, extracted from a fruit which is produced by ingrafting a branch of lemon tree upon the stock of a bergamot pear. It is imported from Italy and Sicily, particularly from Reggia and Messina. This spirit is extracted by paring off the rind of the fruit with a broad knife, pressing the peel between wooden pincers against a sponge, and as soon as the sponge is saturated, the volatile liquor is squeezed into a phial.

Essence *of orange*, and Essence *of lemon*, are prepared in a similar manner, and come from the same countries.

The essences of lavender, of thyme, of rosemary, of anise, of cloves, of cinnamon, &c. are obtained by means of fire.

Essence, in philosophy, that which constitutes the particular nature of each genus or kind, and distinguishes it from all others; being nothing but that abstract idea to which this name is affixed; so that every thing contained in it is essential to that particular kind.

ESSENDI, *quietum de theolonio*, a writ that lies for citizens and burgesses of any city or town, that have a charter on prescription to exempt them from toll through the whole realm, if it happened to be any where exacted of them.

ESSENES, or Essenians, in Jewish antiquity, one of the three ancient sects among that people, who outdid the Pharisees in their most rigorous observances. They allowed a future state, but denied a resurrection from the dead. Their way of life was very singular; they did not marry, but adopted the children of others, whom they bred up in the institutions of their sect; they despised riches, and had all things in common; and never changed their clothes till they were entirely worn out. When initiated, they were strictly bound not to communicate the mysteries of their sect to others; and if any of their members were found guilty of enormous crimes, they were expelled.

ESSENTIAL, something necessarily belonging to the essence or nature of a thing, from which it cannot be conceived distinct; thus the primary qualities of bodies, as extension, figure, number, &c. are essential, or inseparable from them, in all their changes and alterations.

Essential *character*. See Characters.

Essential *oil*, that procured from plants by distillation. See Oil.

Essential *salts*, those obtained from vegetable juices by crystallization. See Salt.

ESSOIN, signifies the allegation of an excuse for him that is summoned, or sought for, to appear and answer to an action real, or to perform suit to a court baron, upon just cause of absence. There are various kinds of excuses which were formerly allowed, but the practice of essoins is obsolete.

ESTABLISHMENT *of dower*, in law, the assurance of dower made to the wife by the husband, or his friends, before or at marriage. Assignment of dower is the setting it out by the heir afterwards, according to the establishment.

ESTATE, in law, that title or interest which a man hath in lands or tenements, &c. This may be considered in a threefold manner: 1. as to the quantity of interest which the party has; 2. the time when that interest is to be enjoyed; 3. the number and connections of the parties who are to enjoy it.

1. The first is measured by its duration or extent, which may be for an uncertain period, during his own life, or the life of another man; to determine at his own decease, or to remain to his descendants after him; or it is for years, months, or days; or infinite and unlimited, being to a man and his heirs for ever. This occasions the division into estates of freehold, and less than freehold. The former is any estate of inheritance or for life, either in a corporeal or incorporeal hereditament, existing in or arising from real property of free tenure; that is now of all which is not copyhold; but tithes and spiritual dues may be freehold, though they issue out of lands not freehold. Freeholds may be considered either as estates of inheritance or not of inheritance. The former are of inheritance absolute, called fee-simple: or inheritance limited, one species of which is called fee-tail. Limit-

ed fees are such estates of inheritance as are clogged with conditions or qualifications, which may be either, 1st. qualified or base fees; or 2d. fees conditional. The former is instanced by a grant to A and his heirs, tenants of the manors of Dale, which may continue for ever, if the heirs of A still continue tenants of Dale; but being subjected to a condition which lowers or debases the certainty of the tenure, it is called a base fee. For fee-tail, see FEE *tail* in this Dictionary, *et post.* Of estates of freehold for life only some may be called conventional, such as are created by act of the parties, others merely legal, or arising by operation of law. For estates for life conventional, see LIFE *estate*. The latter are tenant in tail after possibility of issue extinct, tenant by the curtesy, and tenant in dower, which see.

Of estates less than freehold there are three sorts: 1. estates for years; 2. at will. See LEASE. 3. estates by sufferance. Besides, there are some estates upon condition, as on mortgage estates by statute merchant; statute staple; elegit; which see.

II. Thus far we consider the quantity of the interest. Secondly, as to the time of their enjoyment, which is present or future, they are divided into estates in possession or expectancy. The latter are divided into estates in remainder and reversion, which lead to very nice and abstruse distinctions. See REMAINDER, REVERSION, EXECUTORY DEVISE, LIMITATION, &c. On this head, as to the certainty and time of enjoyment, estates are, 1st. vested in possession: 2d. vested in interest, as reversions; vested remainders; such executory devises, future uses, conditional limitations, &c. as are not referred to or made to depend on a period which is uncertain: 3d. estates contingent, which are referred to a condition or event, which is uncertain whether it may happen or not. An estate is vested, when there is an immediate fixed right of present or future enjoyment. It is vested in possession, when there is a right of present enjoyment; vested in interest, where a present fixed right of future enjoyment. An estate is contingent, when a right of enjoyment is to accrue on an event which is unceraín.

III. With respect to the number of owners, estates in all the above three respects may be held by one or amongst many in four ways, in severalty, in joint tenancy, in coparcenary, or in common. Severalty is the holding lands, &c. as the single owner thereof, which is generally implied where nothing more is said; as to the rest, see JOINT TENANTS and PARCENERS. As to the title to estates, see TITLE; and as to TENURE, see that article.

ESTATES are acquired by different ways, as by descent from a father to a son, which is distinguished from purchase, conveyance or grant from one to another, by deed or by will; and a fee-simple is the largest possible estate, and by the words all his estates, in a deed or will, every thing passes which the party has, and therefore this word creates, in a will or estate in fee, without a limitation to the heirs.

ESTATES are divided into real, such as lands, which descend to the heir, and personal, as chattels, which go to the executor.

ESTOPPEL, in law, an impediment or bar of action arising from a man's own act; or where he is forbidden to speak against his own deed; for by his act or acceptance he may be estopped to speak the truth. There are three kinds of estoppels, *viz.* by matter of record, as by letters patent, fine, recovery, pleading, taking of continuance, confession, imparlance, warrant of attorney, admittance. By matter in writing, deed, &c. or by matter in pais, *i. e.* by some act, such as livery, entry, partition, acceptance of rent, or of an estate. Thus, if a man seized in fee takes a lease of his own land, by this he is estopped, or prevented, from claiming the fee during the term.

ESTOVERS, in law, signifies any kind of allowance out of lands; but in general it is a liberty of taking necessary wood for the use or furniture of a house or farm, and this any tenant may take from off the land let or demised to him, without waiting for any leave, assignment, or appointment of the lessor, unless restrained by special covenant to the contrary.

ESTRAYS and WAIFS. Estrays are any valuable beasts, not wild, found within a lordship, whose owner is not known; such as are commonly impounded and not claimed. They are then to be proclaimed in the church and two nearest market towns on two market days, and not being claimed by the owner, belong to the King, and now commonly, by grant of the crown, to the lord of the manor, or the liberty. Beasts, *feræ naturæ*, cannot be estrays. Swans, but no other fowl, may be estrays. The estray is not the absolute property of the lord till the year and day, with proclamation; and there-

fore if it escape from the lord before, to another manor, he cannot reclaim it. If proclamation is neglected, the owner may claim it without paying the expenses, and may do so at all times within the year and day, upon paying them; but afterwards it is vested in the lord absolutely. The owner may seize it without telling the marks, or proving the property, till the trial; the lord should demand a sum for the keeping it, and the owner may then tender any reasonable sum; the propriety of which, if it is not received, may be ascertained by the jury upon the trial. Amends may be tendered generally, without a particular sum, before the lord fixes the amount. An estray must not be used, but a cow may be milked of necessity. The King's cattle cannot be estrays. The year and day runs from the first proclamation, not the seizure.

Waifs, are goods which are stolen, and waved, or left by the felon on his being pursued, for fear of being apprehended; and forfeited to the King or lord of the manor: and though waifs are generally spoken of things stolen, yet if a man be pursued with hue and cry as a felon, and he flies and leaves his own goods, these will be forfeited as goods stolen; but they are properly the fugitive's goods, and not forfeited till it be found before the coroner, or otherwise of record, that he fled for the felony.

ESTREAT, in law, *extractum*, a true copy, or note, of some original writing or record, and especially of fines and amercements, and imposed in the rolls of a court, and extracted or drawn out from thence, and certified into the court of Exchequer, from whence process is awarded to the sheriff to levy them: in order, therefore, to be relieved from any fine or estreat, application is made to that court upon motion.

ESTREPEMENT, in law, *estrepamentum*, from *estropier mutilare*, or *extirpare*, the spoil made by a tenant for life upon any lands or woods, to the prejudice of the reversioner: also a writ in two cases; the one, when the person having an action depending (as a formedon, writ of right, &c.) for the recovery of the possession of land without damages, sues to prohibit the tenant from making waste during the suit; the other lies after possession is adjudged, but not delivered, and to prevent like waste which is expected. The court of chancery now grants an injunction, on filing a bill and before answer, to prevent waste, and these writs are disused.

ETHER. The action of the more powerful acids on alcohol gives rise to an order of compounds, of some importance from their peculiar properties. These, as produced by the different acids, vary somewhat in their qualities: they also agree, however, in the possession of certain general properties; they are highly volatile, odorous, pungent, and inflammable, miscible with water, and capable of combining with alcohol, in every proportion. These compounds are named ethers; the specific name of each being derived from the acid, from the action of which on alcohol it has originated, as the sulphuric, nitric, muriatic, or acetic ether.

Sulphuric ether has been longest known. The following is the process by which it is prepared

Upon a quantity of alcohol in a retort, (selected thin at the bottom, so as to be capable of bearing a sudden heat,) is poured an equal weight of sulphuric acid, then mixed with the alcohol above by frequent and moderate agitation. From this mixture the alcohol acquires a brownish colour; vapours having a fragrant odour are disengaged; and the temperature rises to about 180 of Fahrenheit. When the mixture of the acid and alcohol is complete, the retort is to be immediately placed in a sand bath, and connected with two large receivers, which are kept cool, by water or ice. Heat is to be immediately applied to the retort. The liquor boils when the temperature is raised to 208, the ether being formed at that temperature and distilling over: the condensation of it is to be promoted, by keeping the receivers cool with water, and the distillation is to be continued till about half the quantity of alcohol employed has distilled over, or until the neck of the retort becomes obscured with white fumes, which condense into a matter of apparently an oily consistence.

The liquor which distils over into the receiver is the sulphuric ether. If, to the residual liquor in the retort, there be added half the quantity of alcohol employed in the first distillation, on applying heat, a new production of ether will take place; and this may be repeated for several times.

Towards the end of the distillation, a portion of sulphurous acid is formed and disengaged, with which the ether is so

far impregnated, that its fragrance is injured, and its odour rendered pungent and acrid. A portion of water likewise distils over, by which it is diluted. The liquor in the retort, at the end of the distillation, is also found diluted with a portion of the water; it is, however, thick, and of a black colour, from a quantity of carbonaceous matter suspended in it.

From the water and sulphurous acid the ether is freed, by subjecting it to a second distillation with a very gentle heat applied by a water-bath, pure potash being previously added to it, in the proportion of two drachms to each pound; this attracts the sulphurous acid, and renders even the water rather less volatile. Another method of rectification, proposed by Pelletier, ("Memoires de Chimie," tom. i. p. 316.) and revived by Dize, ("Nicholson's Journal," 4to. vol. iii. p. 43,) which Mr. Murray, from whose "System" the present article is extracted, found to succeed extremely well, is, to distil the ether of the first distillation from a little black oxide of manganese, the oxygen of which combines with the sulphurous acid, converting it into sulphuric; and this, with the water, remains in the retort. Even after either of these processes, the ether may still contain a portion of alcohol, which usually passes over in the first stage of the distillation. This is best abstracted by agitation with water, which imbibes the alcohol, and a little of the ether; the greater part of the ether floats above, may be drawn off, and by distilling it with a very gentle heat is obtained extremely pure.

A degree of obscurity still prevails with regard to the theory of the formation of sulphuric ether; different views having been entertained of the agency of the acid on the alcohol. The explanation that was generally given, after the establishment of the theory of Lavoisier, was founded on the supposition, that the acid acts principally by communicating oxygen. Alcohol consists of carbon and hydrogen, with a portion of oxygen: when mixed with sulphuric acid, and exposed to heat, it was supposed that part of the acid suffered decomposition, its oxygen being attracted by the hydrogen of the alcohol, and forming water; the balance of attractions between the principles of the alcohol being thus broken, part of its carbon is precipitated, and is diffused through the liquor, rendering it thick and dark coloured; and the remaining quantities of its elements, its carbon, hydrogen, and oxygen, unite and form the ether.

This explanation is founded on the supposition, that the sulphuric acid is decomposed in the process by which ether is formed. But a few years ago it was affirmed by Fourcroy and Vauquelin, from a series of experiments which they undertook to elucidate this subject, that such a decomposition of the acid is not at all necessary to its formation: that although it may take place to a certain extent towards the end of the process, when the liquor is loaded with carbon, there is no indication of it in the first stage, during which, principally, the ether is formed: no sulphurous acid gas is discharged, and if the process be stopped at the end of this stage, the remaining acid, they found, is capable of saturating the same quantity of alkali as before its mixture with the alcohol. ("Nicholson's Journal," 4to. vol. i. p. 385.)

These chemists gave, therefore, a different view of this subject, which they applied even to the action of this acid on vegetable matter in general. They suppose that the sulphuric acid suffers no decomposition, and that it acts no other part than causing, by the exertion of a disposing affinity, the decomposition of the alcohol. By this affinity, it disposes part of the hydrogen and of the oxygen of the alcohol to combine and form water: the balance of attractions being thus subverted, a quantity of carbon is separated, and the remaining carbon, hydrogen, and oxygen, combine and form ether.

This theory, however, advanced by these chemists, is not perhaps perfectly established. Though they affirm, that the acid remaining after the formation of ether saturates as much alkali, as it would do previous to its mixture with the alcohol, the experiment by which this is supposed to be established is not altogether without fallacy. During the formation of ether, there is always, also, a formation from the elements of the alcohol, of some of the vegetable acids, particularly of the acetous and oxalic. The oxalic, it has been ascertained by the observation of Cadet, is formed copiously even without heat, merely by allowing the mixture of acid and alcohol to remain at rest for some time. These will contribute to the saturation of the alkali; so that if none of the sulphuric acid were decomposed, more alkali ought

in reality to be saturated by it after, than before, its mixture with the alcohol.

There are also some facts which appear to prove the necessity of the presence of some substance that can part with its oxygen, for the production of ether. Thus, ether cannot be formed from the muriatic acid, but it can with facility from the oxymuriatic; it is likewise formed with great rapidity by the nitric acid; neither of which can exert a strong disposing affinity to water, though both very readily part with their oxygen.

Whatever opinion, however, may be formed as to the manner in which the changes that take place during the formation of ether are produced, the nature of the changes themselves seems sufficiently well ascertained. It is proved, that a quantity of the hydrogen of the alcohol is expended in the formation of water, as the remaining acid is always in a diluted state: a still larger quantity of carbon is also separated, and is mechanically diffused through the liquor. The ether, therefore, which is the only other product of the operation, is to be considered as a compound of hydrogen and carbon, and perhaps oxygen; differing from alcohol, in containing a much larger quantity of hydrogen, proportioned to its carbon; and to this predominance of hydrogen its great levity and volatility are owing. This conclusion is confirmed, by its analysis by combustion, the products of which are water and carbonic acid; the former being derived from the combination of its hydrogen with the oxygen of the air, the latter from the same combination of its carbon. Mr. Cruikshank found, that the vapour of ether requires about seven times its volume of oxygen to saturate it in combustion; the products being water and carbonic acid gas, the latter amounting to 4.6 parts by measure. From this result, compared with a similar experiment on alcohol, he inferred, that the proportion of carbon to hydrogen in the ether is as 5 to 1 nearly, while in alcohol it is as 8 or 9 to 1. ("Nicholson's Journal," 4to. vol. v. p. 205.)

Besides ether, there are some other products formed during the action of sulphuric acid upon alcohol. Towards the end of the process an oily-like matter distils over, which has been named Sweet Oil of Wine. This can be obtained separate, by changing the receiver: it is unctuous, thick, and less volatile than the ether, but is soluble both in it and in alcohol. It is obtained, likewise, by distilling sulphuric ether from a fresh quantity of acid. Chemists are not agreed respecting its nature: Fourcroy and Vauquelin consider it as similar to ether, and that it differs from that fluid, principally, in containing a larger proportion of carbon, which gives to it more density and less volatility. Other chemists, particularly Higgins, have affirmed, that it is a compound of ether and sulphurous acid, and that by the addition of an alkali, which combines with the acid, a quantity of ether may be obtained from it. It does not appear, however, that this combination can be formed directly, or that ether can combine with a large quantity of sulphurous acid, so as to assume the properties of oil of wine; and though this substance may contain a portion of this acid, it is not improbable that it also differs from ether in its ultimate composition. At the same time that the oil of wine is disengaged, there is formed a quantity of olefiant gas, which passes off. It was in this process, indeed, that the production of this gas was first observed; and the action of sulphuric acid on alcohol still affords us the best method of obtaining it pure. The same gas is produced, by passing the vapour of ether through an ignited earthen tube; but when a glass tube is used, a different variety of carburetted hydrogen is obtained.

At this stage of the process the liquor becomes so loaded with carbon, and at the same time is capable of bearing so high a temperature, that if the heat is kept up, the sulphuric acid is decomposed, and a large quantity of sulphurous acid gas and carbonic acid is produced. If the greatest care is not taken to keep the heat moderate, the whole liquor is apt to swell suddenly up, and boil over into the receiver. If examined at this time, it is likewise found to contain a portion of acetic and oxalic acids mixed with the sulphuric acid, which is diluted with water, and through which the carbon is diffused. Sulphuric ether, when highly rectified, is the lightest of all known liquids. It is obtained without difficulty of the specific gravity of .732, and by careful distillation has been brought so low as .716. It is colourless, and perfectly transparent; has a strong pungent taste, and a fragrant penetrating smell.

It is likewise the most volatile liquid. It evaporates rapidly, even at the common temperature, and under the com-

mon pressure of the atmosphere; so that it cannot be poured from one vessel into another without loss, and any part wet with it immediately becomes dry. In vacuo it boils at a temperature considerably below 32°: under the atmospheric pressure it boils at 98. In the spontaneous evaporation of ether a large quantity of caloric is absorbed, so as to produce cold: water inclosed in a small tube may be easily frozen, by ether evaporating from a piece of muslin wrapt round the external surface of the tube; and Dr. Higgins has observed, that in the rapid evaporation of ether, the temperature in frosty weather falls so low as 40. Ether congeals at 47.

Ether is highly inflammable, and, when kindled, burns with a clear white flame, without any smoke, and without leaving any residuum, the products of its combustion being water and carbonic acid: the residual water generally gives indications too of sulphuric acid, which may either be adventitious, or perhaps is essential to the constitution of this species of ether. From its high inflammability, its vapour diffused in the atmosphere sometimes takes fire; or if a drop or two of ether be added to atmospheric air, or oxygen gas, an explosion happens on the contact of an ignited body.

Sulphuric ether is soluble in water; but only in a limited proportion. When highly rectified, it requires ten parts of water for its solution; and this is a property by which we are enabled to determine its purity, as, if more soluble, it contains either water or alcohol. It is soluble in alcohol in every proportion.

Sulphuric ether exerts no sensible action on the fixed alkalies or earths. It unites with ammonia by distillation.

Neither does it act on the metals; but it is capable of decomposing the saline combinations of those that have a weak affinity to oxygen, by attracting that principle. Thus, muriate of gold dissolved in it is gradually decomposed, and the gold precipitated in its metallic form.

On the simple inflammables its action is somewhat similar to that of alcohol. It dissolves sulphur, as Favre has shown, one ounce of ether dissolving about 25 grains; the solution has a strong sulphurous smell and taste; it is less soluble in water than pure ether, and deposits sulphur as the ether volatilizes. ("Nicholson's Journal," vol. xiii. p. 69.) Ether likewise dissolves a small proportion of phosphorus; this solution, like the phosphuretted alcohol, is decomposed by water; but does not, like it, appear luminous during the decomposition.

Sulphuric ether is a solvent of many of the vegetable proximate principles, as the essential oils, camphor, and resins. It is also, as has already been remarked. the most powerful solvent of caoutchouc.

In medicine it is employed as a diffusible stimulant.

Nitric Ether. The action of nitric acid on alcohol is so violent, that the formation of nitric ether is extremely difficult, and requires considerable precaution. One part of the acid may be added gradually to three parts of alcohol without any risk; and after standing for some days, to allow of their reciprocal action, heat may be applied, when a portion of nitric ether that has been formed distils over, with a quantity of unchanged alcohol. A preparation of this kind has been long known in pharmacy, under the name of sweet spirit of nitre. But when the proportion of acid is increased, the action becomes very violent; a quantity of aërial fluid is suddenly formed, and disengaged at each addition; and it requires particular arrangements, to admit of so much acid being added, as is sufficient to convert the whole of the alcohol into ether.

The method proposed by Navier is, to put into a strong earthenware bottle twelve parts of alcohol, and immerse it in water or ice; eight parts of nitrous acid are to be added in successive portions, mixing them by agitation at each addition; the bottle is well corked, and tied over, and is put in a cool place. At the end of six days the cork is to be perforated, to allow a quantity of gaseous fluid that has been formed, and is retained by compression, to escape. The bottle is then uncorked, the liquid poured into a funnel, and the acid liquor beneath allowed to run off from the ether which swims above.

An ingenious method, somewhat similar, but less hazardous, was employed by Dr. Black. He first poured into a strong flint glass bottle six ounces of alcohol; then, by a funnel, the tube of which reached to the bottom of the bottle, he poured in two ounces of water, gently, so that it did not mix with the alcohol, but raised it above it; and, lastly, he poured in four ounces of nitrous acid in the same manner, so that the small column of water was interposed between it and the alcohol. The phial was set aside for some

time in a cool place: the water attracted the alcohol at the one surface, the acid at the other, and thus brought them very gradually together, so as to admit of their reciprocal action without violence. At the end of a few months they were completely mixed, and nitric ether formed, which floated above, was withdrawn and rectified by distillation.

The theory of the formation of nitric ether is as obscure as that of sulphuric ether. It is ascertained, however, that even from the commencement of the process the acid is decomposed; nitric oxide gas is disengaged; and Pelletier found that the decomposition was complete, nitric acid not being discoverable, either in the liquor which passed over, or in the residuum.

It is also proved, that in the formation of nitric ether the alcohol suffers decomposition, as in the residual liquor oxalic and acetic acids are formed. There is no deposition, however, of carbonaceous matter, as there is in the formation of sulphuric ether, the residual liquor being quite transparent and of a light colour. It appears to follow, therefore, from these facts, that in the formation of nitric ether part of the elements of the alcohol combine with oxygen from the nitric acid, and form oxalic and acetic acids; carbonic acid gas too is formed and disengaged, as Pelletier found, in considerable quantity, and much of the nitric acid mixed with nitric oxide and nitrogen gases. (Mémoires de Chimie, tom. i. p. 138.)

It is difficult, however, to determine in what manner these facts are to be combined, so as to give with precision the theory of the formation of nitric ether: nor is it very apparent, whether any of the elements of the nitric acid enter into its composition, or whether they are entirely disengaged during the process. It might be supposed, that it must contain more carbon than sulphuric ether, as none is deposited during its formation; but we are not certain what quantity is carried off in the state of carbonic acid.

Nitric ether has some resemblance in its properties to sulphuric ether. Like it, it is light and volatile, and has been said, when highly rectified, to have these qualities even in a higher degree than sulphuric ether. It is also inflammable, burns with an enlarged flame, and is said to deposit more charcoal. It is soluble in water and in alcohol. Its odour is strong, though scarcely so agreeable as that of sulphuric ether; in the state, however, of what has been named dulcified spirit of nitre, it is more fragrant. Its colour is usually yellow; but this, as well probably as some of its other qualities, appears rather to be owing to the presence of nitric acid, surcharged perhaps with nitric oxide.

Muriatic ether. Pelletier proposes the following process to form muriatic ether: place a retort in a sand-bath, and connect it with a glass balloon, and two of Woulfe's bottles: put into the bottle 100 parts of muriate of soda, perfectly dry, and into the balloon and bottles the same quantity of alcohol. The joinings being luted, 50 parts of sulphuric acid are to be poured on the salt, and the operation is left to proceed in the cold for five or six hours. A moderate heat is then to be gradually applied. The muriatic acid gas passes over, and is condensed by the alcohol. The whole of this liquor is then put into a retort, with twenty parts of oxide of manganese in fine powder; and there is put into the receiver and bottles a solution of pure potash. It is distilled by a gentle heat: the muriatic ether passes over, and the reaction of any excess of oxymuriatic acid gas upon it, which would change it to oil, is prevented by the alkali. The ether is then to be rectified, by mixing it with twice its bulk of water, and distilling it by a very gentle heat.

The properties of muriatic ether have not been properly described, from the difficulty of obtaining it pure. It is said to be light, transparent, volatile, and ininflammable, emitting while burning a pungent odour, and to have a styptic taste.

A process has been given by Boudet for the preparation of *phosphoric ether*. He mixed liquid phosphoric acid of a thick consistence and alcohol in equal proportions, introduced the mixture into a tubulated retort connected with a receiver, and with an Woulfe's bottle, which was filled two-thirds with lime-water: heat was applied, so as to cause the mixture to boil; a portion of unchanged alcohol first distilled over; this was succeeded by a liquor having an ethereal odour, mixed a little with that of garlic: it reddened slightly the syrup of violets: when rectified by distillation, with the addition of carbonate of magnesia, the product was colourless, and had an odour somewhat similar to that of sulphuric ether: it was volatile, and highly inflammable, its combustion not being accompanied with any smoke. It floated on the surface of water, but by agitation

with it was dissolved. It dissolved the volatile oils, and also phosphorus. Its specific gravity was inferior to that of alcohol, being as 94 to 100. After its production, when the heat was much raised, a quantity of oily matter was distilled over, and carburetted hydrogen was disengaged, the residual liquor was of a dark brown colour, and contained a large quantity of phosphoric acid. (Annales de Chimie, tom. xi. p. 123.)

Fluoric ether has been said to be formed by putting fluate of lime, previously ignited and in powder, into a retort, with equal weights of alcohol and sulphuric acid, and distilling to dryness. The product of this distillation was again distilled to one half, and a portion of fluoric acid abstracted from it by a solution of potash, which at the same time precipitated a portion of silex, so as to render the whole gelatinous. This, on being again distilled, afforded an ether of the specific gravity of 0.720, which burnt with a blue flame, and had a bitter taste. It is added, that it greatly resembled sulphuric ether; and it is not improbable that it may have been merely this ether disguised. (Nicholson's Journal, vol. viii. p. 143.)

Acetic ether has been known for a considerable time to chemists, Lauragais having given, in 1759, the process for preparing it, by distilling alcohol, with the concentrated acetic acid that is procured by the decomposition of acetate of copper by heat. Scheele, as well as other chemists, have been unable to form it; but Pelletier has observed that it is procured with certainty by distilling alcohol repeatedly from the acetic acid. The alcohol at first acquires an ethereal odour, but is miscible with water; by returning it on the residual liquor, distilling it, and repeating this for a third time, this becomes stronger: the acid contained in the liquor thus procured was saturated by the addition of carbonate of potash; and by distillation there was procured from it a pure acetic ether, in quantity about half of the alcohol employed. ("Mémoirs de Chimie," tom. i. p. 237.) It was soluble in water in a limited quantity, seven measures dissolving three. It has an agreeable odour, ethereal, but in which the smell of acetic acid is also perceptible. It is very volatile and inflammable: it burns with a clear light, and leaves a little charcoal.

According to Pelletier, acetic ether may likewise be formed by distillation, from a mixture of sulphuric acid, acetate of copper, and alcohol; and according to Laplanche, it may be obtained from a mixture of sulphuric acid, alcohol, and acetate of lead.

ETHER *of Sir Isaac Newton*. When we have separated the actions of bodies upon each other, so far that the effects appear to us to be simple, we resolve the causes of motion into two; namely, a disposition of bodies to come together, called attraction, and a disposition to recede from each other, called repulsion. Impulse, or the communication of motion by apparent contact, will not constitute a peculiar case, because we know that bodies cannot be, or are not, in any of our observations, brought close to each other. But as in all our philosophising we endeavour to simplify the general principles, it becomes a question, whether the effects of attraction and repulsion may not depend upon the same cause; and as we have many gross instances of bodies being urged together by the action of fluids, it naturally occurs to enquire, whether the apparent attractions in nature may not be caused by some fluid medium. Sir Isaac Newton was strongly of this opinion, as appears by his letter to Boyle, published in Birch's life of that philosopher, as well as by the famous paragraph at the end of his "Principia," and one of the queries at the end of his "Optics," in the preface to the second edition of which he remarks, that he does not take gravity for an essential property of bodies. In the query here mentioned, he proceeds upon the supposition of an elastic medium pervading all space; a supposition which he advances with considerable confidence, and which he supports by very strong arguments, deduced as well from the phenomena of light and heat, as from the analogy of the electric and magnetic influences. This medium he supposes to be much rarer within the dense bodies of the sun, the planets, and the comets, than in the empty celestial spaces between them, and to grow more and more dense at greater distances from them, so that all these bodies are naturally forced towards each other by the excess of pressure.

The effects of gravitation might be produced by a medium thus constituted, if its particles were repelled, by all material substances, with a force decreasing like other repulsive forces, simply as the distances increase; its density would then be every way such as to produce the appearance of an attraction varying like that of gravitation: such an ethereal me-

dium would therefore have the advantage of simplicity in the original law of its action, since the repulsive force, which is known to belong to all matter, would be sufficient, when thus modified, to account for the principal phenomena of attraction.

It may be questioned whether a medium, capable of producing the effects of gravitation in this manner, would also be equally susceptible of those modifications which we have supposed to be necessary for the transmission of light: in either case it must be supposed to pass through the apparent substance of all material bodies with the most perfect freedom, and there would, therefore, be no occasion to apprehend any difficulty from a retardation of the celestial motions; the ultimate impenetrable particles of matter being perhaps scattered as thinly through its external form as the stars are scattered in a nebula, which has still the distant appearance of an uniform light, and of a continuous surface: and there seems no reason to doubt the possibility of the propagation of an undulation through the Newtonian medium, with the actual velocity of light. It must be remembered, that the difference of its pressure is not to be estimated from the actual bulk of the earth, or any other planet alone, but from the effect of the sphere of repulsion of which that planet is the centre; and we may then deduce the force of gravitation from a medium of no very enormous elasticity.

A similar combination of a simple pressure with a variable repulsion is also observable in the force of cohesion; and Dr. Young, in his Lectures, remarks, that supposing two particles of matter floating in such an elastic medium, capable of producing gravitation, to approach each other, their mutual attraction would at once be changed from gravitation to cohesion, upon the exclusion of the portion of the medium intervening between them: this supposition is, however, as he adds, directly opposite to that which assigns to the elastic medium the power of passing freely through all the interstices of the ultimate atoms cohering in this manner; but that, as we see some effects so nearly resembling them, which are unquestionably produced by the pressure of the atmosphere, we can scarcely avoid suspecting that there must be some analogy in the causes.

Two plates of metal, which cohere enough to support each other in the open air, will often separate in a vacuum. When a boy draws along a stone by a piece of wet leather, the pressure of the atmosphere seems to be materially concerned. The well-known experiment of the two exhausted hemispheres of Magdeburgh affords a still more striking instance of apparent cohesion, derived from atmospherical pressure: and if we place between them a thick ring of elastic gum, we may represent the natural equilibrium between the forces of cohesion and of repulsion; for the ring would resist any small additional pressure, with the same force as would be required for separating the hemispheres, so far as to allow it to expand in an equal degree; and at a certain point the ring would expand no more, the air would be admitted, and the cohesion destroyed in the same manner as when a solid of any kind is torn asunder.

But all suppositions founded on these analogies must be considered as merely conjectural; and our knowledge of every thing which relates to the intimate constitution of matter, partly from the intricacy of the subject, and partly for want of sufficient experiments, is at present in a state of great uncertainty and imperfection.

ETHICS, or Morality, the science of manners or duty, which it traces from man's nature and condition, and shews to terminate in his happiness: or, in other words, it is the knowledge of our duty and felicity, or the art of being virtuous and happy. See Moral Philosophy.

ETHULIA, in botany, a genus of the Syngenesia Polygamia Æqualis class and order. Natural order of Compositæ Discoideæ. Corymbiferæ, Jussieu. Essential character: receptacle naked; down none. There are six species.

ETYMOLOGY, that part of grammar which considers and explains the origin and derivation of words, in order to arrive at their first and primary signification, whence Quintilian calls it *originatio*. See Grammar.

EVAPORATION, in natural philosophy, is the conversion of water into vapour, which, in consequence of becoming lighter than the atmosphere, is raised considerably above the surface of the earth, and afterwards by a partial condensation forms clouds. It differs from exhalation, which is properly a dispersion of dry particles from a body. When water is heated to 212°, it boils, and is rapidly converted into steam; and the same change takes place in much lower temperatures; but in that case the evapora-

tion is slower, and the elasticity of the steam is smaller. As a very considerable proportion of the earth's surface is covered with water, and as this water is constantly evaporating and mixing with the atmosphere in the state of vapour, a precise determination of the rate of evaporation must be of very great importance in meteorology. Accordingly, many experiments have been made to determine the point by different philosophers. No person has succeeded so completely as Mr. Dalton: but many curious particulars had been previously ascertained by the labours of Richman, Lambert, Watson, Saussure, De Luc, Kirwan, and others. From these we learn that, 1. the evaporation is confined entirely to the surface of the water; hence it is in all cases proportional to the surface of the water exposed to the atmosphere. Much more vapour of course rises in maritime countries, or those interspersed with lakes, than in inland countries. 2. Much more vapour rises during hot weather than during cold; hence the quantity evaporated depends in some measure upon temperature. The precise law has been happily discovered by Mr. Dalton, who says, in general, the quantity evaporated from a given surface of water per minute, at any temperature, is to the quantity evaporated from the same surface at 212°, as the force of vapour at the first temperature is to the force of vapour at 212°. Hence, in order to discover the quantity which will be lost by evaporation from water of a given temperature, we have only to ascertain the force of vapour at that temperature. Hence, we see that the presence of atmospheric air obstructs the evaporation of water; but this evaporation is overcome in proportion to the force of the vapour. Mr. Dalton ascribes this obstruction to the *vis inertiæ* of air. 3. The quantity of vapour which rises from water, even when the temperature is the same, varies according to circumstances. It is least of all in calm weather, greater when a breeze blows, and greatest of all with a strong wind. Mr. Dalton has given a table, that shews the quantity of vapour raised from a circular surface of six inches in diameter in atmospheric temperatures. The first column expresses the temperature; the second the corresponding force of vapour; the other three columns give the number of grains of water that would be evaporated from a surface of six inches in diameter in the respective temperatures, on the supposition of there being previously no aqueous vapour in the atmosphere. These columns present the extremes, and the mean of evaporation likely to be noticed, or nearly such; for the first is calculated upon the supposition of 35 grains loss per minute, from the vessel of $3\frac{1}{2}$ inches in diameter; the second 45, and the third 55 grains per minute. 4. Such is the quantity of vapour which would rise in different circumstances, on the supposition that no vapour existed in the atmosphere. But this is a supposition which can never be admitted, as the atmosphere is in no case totally free from vapour. Now, when we wish to ascertain the rate at which evaporation is going on, we have only to find the force of the vapour already in the atmosphere, and subtract it from the force of vapour at the given temperature; the remainder gives us the actual force of evaporation; from which, by the table, we readily find the rate of evaporation. Thus, suppose we wish to know the rate of evaporation at the temperature 59°. From the table, we see that the force of vapour at 59° is 0.5, or $\frac{1}{60}$ its force at 212°. Suppose we find, by trials, that the force of the vapour already existing in the atmosphere is 0.25, or the half of $\frac{1}{60}$. To ascertain the rate of evaporation, we must subtract the 0.25 from 0.5; the remainder 0.25 gives us the force of evaporation required; which is precisely one half of what it would be, if no vapour had previously existed in the atmosphere. 5. As the force of the vapour actually in the atmosphere is seldom equal to the force of vapour of the temperature of the atmosphere, evaporation, with a few exceptions, may be considered as constantly going on. Various attempts have been made to ascertain the quantity evaporated in the course of a year; but the difficulty of the problem is so great, that we can expect only an approximation towards a solution.

The most exact set of experiments on the evaporation from the earth was made by Mr. Dalton and Mr. Hoyle, during 1796, and the two succeeding years. The method which they adopted was this: having got a cylindrical vessel of tinned iron, ten inches in diameter, and three feet deep, there were inserted into it two pipes turned downwards, for the water to run off into bottles: the one pipe was near the bottom of the vessel, the other was an inch from the top. The vessel was filled up for a few inches with gravel and sand, and all the rest with good fresh soil. It was then put into a hole in the

ground, and the space around filled up with earth, except on one side, for the convenience of putting bottles to the two pipes; then some water was poured on to sodden the earth, and as much of it as would was suffered to run through without notice, by which the earth might be considered as saturated with water. For some weeks the soil was kept above the level of the upper pipe, but latterly it was constantly a little below it, which precluded any water running off through it. For the first year the soil at top was bare; but for the two last years it was covered with grass, the same as any green field. Things being thus circumstanced, a regular register was kept of the quantity of rain water that ran off from the surface of the earth through the upper pipe, (whilst that took place,) and also of the quantity of that which sunk down through the three feet of earth, and ran out through the lower pipe. A rain guage of the same diameter was kept close by, to find the quantity of rain for any corresponding time. The weight of the water which ran through the pipes being subtracted from the water in the rain guage, the remainder was considered as the weight of the water evaporated from the earth in the vessel. From these experiments it appears, that the quantity of vapour raised annually at Manchester is about 25 inches. If to this we add five inches for the dew, with Mr. Dalton, it will make the annual evaporation 30 inches. Now, if we consider the situation of England, and the greater quantity of vapour raised from water, it will not surely be considered as too great an allowance, if we estimate the mean annual evaporation over the whole surface of the globe at 35 inches. Now, 35 inches from every square inch, on the superficies of the globe, make 94,450 cubic miles, equal to the water annually evaporated over the whole globe. Was this prodigious mass of water all to subsist in the atmosphere at once, it would increase its mass by about a twelfth, and raise the barometer nearly three inches: but this never happens; no day passes without rain in some part of the earth; so that part of the evaporated water is constantly precipitated again. Indeed, it would be impossible for the whole of the evaporated water to subsist in the atmosphere at once, at least in the state of vapour. See Manchester Memoirs.

EUCALYPTUS, in botany, a genus of the Icosandria Monogynia class and order. Essential character: calyx superior, permanent, truncate, before flowering time covered with a hemispherical, deciduous lid; corolla none; capsules four-celled, opening at the top, inclosing many seeds. There are two species, *viz.* E. obliqua; oblique leafed eucalyptis; and E. resinifera, red gum tree. These are both very large and lofty trees, much exceeding the English oak both in height and bulk. E. resinifera, contains a large quantity of resinous gum; the wood is of a brittle quality; the flowers grow in little clusters, or rather umbels, about ten in each, and every flower has its proper partial foot stalk, a quarter of an inch in length, besides the general one; the flowers are yellowish, and of a singular structure; the calyx is hemispherical, perfectly entire on the margin; it afterwards becomes the capsule; the anthers are small and red; in the centre is a single style, terminated by a blunt stigma; the stamens are resinous and aromatic; the germ appears when cut across to be divided into three cells, each containing the rudiments of one or more seeds.

EUCLEA, in botany, a genus of the Dioecia Dodecandria, or Polygamia class and order. Essential character: male calyx four or five-toothed; corolla four or five-parted; stamens twelve to fifteen: female calyx and corolla as in the male; germ superior; styles two; berry two-celled. There is but one species, *viz.* E. racemosa, round-leaved euclea, a native of the Cape of Good Hope.

EUCLID, of Megara, a celebrated philosopher and logician; he was a disciple of Socrates, and flourished about 400 years before Christ. The Athenians having prohibited the Megarians from entering their city, on pain of death, this philosopher disguised himself in women's clothes to attend the lectures of Socrates. After the death of Socrates, Plato and other philosophers went to Euclid at Megara, to shelter themselves from the tyrants who governed Athens. This philosopher admitted but one chief good; which he at different times called God, or the Spirit, or Providence.

Euclid, the celebrated mathematician, according to the account of Pappus and Proclus, was born at Alexandria, in Egypt, where he flourished and taught mathematics, with great applause, under the reign of Ptolemy Lagos, about 280 years before Christ. And here, from his time till the conquest of Alexandria by the Saracens, all the eminent mathematicians were either born or studied; and it is to Euclid, and his scholars, we are beholden

for Eradtosthenes, Achimedes, Apollonius, Ptolemy, Theon, &c. &c. He reduced into regularity and order all the fundamental principles of pure mathematics, which had been delivered down by Thales, Pythagoras, Eudoxus, and other mathematicians before him, and added many others of his own discovering: on which account it is said he was the first who reduced arithmetic and geometry into the form of a science. He likewise applied himself to the study of mixed mathematics, particularly to astronomy and optics.

His works, as we learn from Pappus and Proclus, are, the Elements, Data, Introduction to Harmony, Phenomena, Optics, Catoptrics, a Treatise of the Division of Superficies, Porisms, Loci ad Superficiem, Fallacies, and four books of Conics.

The most celebrated of these is the first work, the "Elements of Geometry;" of which there have been numberless editions, in all languages; and a fine edition of all his works, now extant, was printed in 1703, by David Gregory, Savilian Professor of Astronmy at Oxford.

The "Elements," as commonly published, consist of fifteen books, of which the two last, it is suspected, are not Euclid's, but a comment of Hypsicles of Alexandria, who lived 200 years after Euclid. They are divided into three parts, *viz.* The contemplation of Superficies, Numbers, and Solids; the first four books treat of planes only; the fifth of the proportions of magnitudes in general; the sixth of the proportion of plane figures; the seventh, eight, and ninth, give us the fundamental properties of numbers; the tenth contains the theory of commensurable and incommensurable lines and spaees; the eleventh, twelfth, thirteenth, fourteenth, and fifteenth, treat of the doctrine of solids.

There is no doubt but, before Euclid, elements of geometry were compiled by Hippocrates of Chius, Eudoxus, Leon, and many others, mentioned by Proclus, in the beginning of his second book; for he affirms, that Euclid new ordered many things in the Elements of Eudoxus, completed many things in those of Theatetus, and besides strengthened such propositions as before were too slightly, or but superficially, established, with the most firm and convincing demonstrations.

History is silent as to the time of Euclid's death, or his age. He is represented as a person of a courteous and agreeable behaviour, and in great esteem and familiarity with King Ptolemy; who once asking him whether there was any shorter way of coming at geometry than by his Elements, Euclid, as Proclus testifies, made answer, that there was no other royal way or path to geometry.

EUCOMIS, in botany, a genus of the Hexandria Monogynia class and order. Natural order of Coronariæ. Asphodeli, Jussieu. Essential character: corolla inferior, six-parted, permanent, spreading; filaments united at the base into a nectary growing to the corolla. There are four species, all natives of the Cape.

EUDIOMETRY. The measurement of the quantity of oxygen contained in atmospheric air, or indeed in any gas in which it is not intimately combined, is named eudiometry, and the instrument by which it is performed, the eudiometer. To attain such a measurement, it is merely necessary to present to atmospheric air some substance, which combines with its oxygen, and which either does not afford any gaseous product, or affords one that is easily abstracted and measured. Different substances have been applied to this purpose.

The fluid originally employed by Scheele, in the analysis of the air, the solution of sulphuret of potash, or, what is rather more convenient, the sulphuret of lime is perhaps superior in accuracy to any, at least if the air be not too long exposed to it, and be not in too small a quantity proportioned to the quantity of fluid. Phosphorus is applied by a very simple apparatus, but, by its solubility in nitrogen gas, it adds to the bulk of the residual air, for which a correction must be made. Nitrous gas was employed by Priestley; it exhibits the result immediately, but is liable to several sources of fallacy. Hydrogen gas was employed by Volta: a given measure of it being put along with a quantity of the air designed to be submitted to trial into a graduated tube, and inflamed by the electric spark, the diminution of volume indicating the quantity of oxygen; 100 measures of oxygen require rather less than 200 measures of hydrogen for saturation; about 40 measures of hydrogen are therefore sufficient to saturate the oxygen contained in 100 measures of atmospheric air, but it is proper to use an excess of hydrogen, as otherwise part of the oxygen is liable to escape combination. From 60 of hydrogen, with 100 of atmospheric air, Mr. Dalton states that the residuum, after explosion, is 100, 21 of oxygen combining with 39 of hydrogen. The method is

simple and expeditious, and as Humbolt and Gay Lussac have remarked, has the great advantage, from the bulk of the mixture, and the great diminution of volume, from the consumption of a given quantity of oxygen, of being more delicate than any other. It also requires no corrections for variations of temperature or atmospheric pressure; and any impurity in the hydrogen gas, which it has been supposed might be a source of error, may by avoided by care. It affords also the best method of determining the purity of oxygen gas, or the proportion of oxygen in any mixed gas containing it. Humbolt, and Gay Lussac in an elaborate memoir, have pointed out all the circumstances to be attended to in employing it as an eudiometer. (Journal de Physique, t. lx. p. 129.)

From the practice of eudiometry, it was at one time expected, as the name implies, that we should be able to ascertain the purity of the air with regard to its salutary or noxious power on life. It was soon found, however, particularly by Priestley, (and the fact has also sincebeen established by de Marti,) that the air of places the most offensive and unhealthy afforded as much oxygen as that of others of an opposite description; the air, for example, of crowded cities, of low, damp situations, or of crowded manufactories, has not been found less pure than that of the country; the noxious quality of the air depending not so much on any deficiency of oxygen, as on the presence of effluvia not discoverable by this test.

It was at one time imagined, that the composition of atmospheric air is not uniform, but that it varies both at different parts of the earth's surface; and still more at different heights. Ingenhouz made a number of experiments to prove the former fact, from which he concluded, that the air is purer, or contains more oxygen at sea than on land, and that in the neighbourhood of marshy situations it contains less oxygen than the standard. (Philosophical Transactions, vol. lxx. p. 354.)

Saussure made some experiments on the air at some of the elevated parts of the Alps, the summit of the great St. Bernard, the Buet, &c.: in this air the proportion of oxygen was less than in the air on the plains. (Voyages, t. ii. p. 357; t. iv. p. 451)

Von Humbolt relates, also, that air brought from a great height in the atmosphere, by a person who had ascended in a balloon, contained in 100 parts 25.9 of oxygen, while air at the surface contained 27.6; and that at the summit of the Peak of Teneriffe, the proportion of oxygen amounted only to 19, while at the foot of the mountain it was 27. The proportions which he states prove sufficiently the error of the eudiometrical method he employed, and the eudiometer he did use; that with nitrous gas, corrected by trying its purity with sulphate of iron, is indeed the one which is most liable to fallacy. The analysis of the air in the upper regions of the atmosphere has since been executed with accuracy by Gay Lussac, assisted by Thenard. A glass balloon was filled with air, at the height of 21.735 feet from the surface, the greatest which has yet been reached, and when opened under water by Gay Lussac, after his descent, one half of its capacity was filled by the water, a sufficient proof that it had been accurately closed. The air was subjected to trial, both by Volta's eudiometer, and by the solution of sulphuret of potash; it afforded by the former method 21.49 of oxygen in 100; by the latter 21.63. Atmospheric air at the surface, analysed at the same time in the eudiometer of Volta, gave precisely the same result, 21.49. (Nicholson's Journal, vol. x. p. 286.)

Saussure, junior, also found, that the air on the summit of the Col-du-Geant, contained within one-hundreth part as much oxygen as that on the plain, and even this difference may be ascribed to the difficulty of making the experiment with perfect accuracy. The uniformity of the composition of the atmosphere at different parts of the earth's surface appears also to be established.

Mr. Cavendish originally observed, that air subjected to examination at different times, and air likewise from different places, was of perfectly similar composition: (Philosophical Transactions, vol. lxxiii. p. 129;) and the same observation had been made by Fontana, from his own experiments. (Philosophical Transactions, vol. lxix.)

Mr. Davy states, that no sensible difference was found in the air sent from the coast of Guinea, and the air in England. (Journal of the Royal Institution, vol. i. p. 48.)

Berthollet found, that the air in Egypt and in France was similar, affording 22 of oxygen in the 100, any difference observed not amounting to a two-hundredth part of the air submitted to trial. (Memoirs relative to Egypt, p. 326.)

De Marti, by experiments in Spain, obtained the same uniformity of composition (between 21 and 20 of oxygen in the hundred parts) in the air, at places at a distance from each other; and he adds also, as established by his experiments, that in every state of the atmosphere, whether with regard to temperature, to pressure, as indicated by the barometer, to winds, to humidity, to the season of the year, or the hour of the day or night, the results were precisely the same. (Journal de Physique, t. iii. p. 173.) and more lately the researches of Humboldt and Gay Lussac, made with the view of determining this question, have established the same conclusion. (Journal de Physique, t. lx. p. 152.)

The instruments for subjecting atmospheric air to such changes as may indicate its proportion of oxygen have been called eudiometers. When a mixture of nitrous gas is to be made with atmospheric air, the most convenient apparatus consists in a glass tube, closed at top, and graduated by a diamond into cubic inches and parts. The lower aperture may be widened, in order that the gases may more easily be passed up, and likewise to afford the facility of its standing alone upon the pneumatic shelf. It is likewise usual and advantageous to fit a stopper in the mouth by grinding; a cubic inch measure will be required for determining the quantities poured up. A bottle will do for this purpose, and the instrument may be made very well by a chemist, who is obliged to work for himself, by taking any small bottle whatever, and pouring its contents of water, by successive times, into the tube placed mouth upwards. By this means he will obtain a graduation, which, whether of the cubic inch or not, will answer the purposes of eudiometry.

When air is to be exposed to a liquid sulphuret, which absorbs the oxygen, the eudiometric tube may be immersed in the liquid. Professor Hope, of Edinburgh, has contrived a very simple, elegant, and accurate apparatus for this purpose, announced in "Nicholson's Journal," iv. 210. It consists of a small bottle, of the contents of about three ounces, intended to contain the eudiometric liquid; into the neck a tube is accurately fitted by grinding, which holds precisely a cubic inch, and is divided into a hundred equal parts, and on one side the bottle, near its bottom, there is a neck, into which a stopper is ground in the usual manner. In the use of this apparatus, the bottle is first filled with the liquid employed, which is best prepared by boiling a mixture of quick lime and sulphur with water, filtering the solution, and agitating it for some time in a bottle half filled with common air. The tube, filled with the gas under examination, or with common air, if that be the subject of the experiment, is next put into its place, and on inverting the instrument, the gas ascends into the bottle, where it is brought extensively into contact with the liquid, by brisk agitation. An absorption of oxygen, if present, ensues, and, to supply its place, the stopper in the side of the bottle is opened under water, a quantity of which rushes into the bottle; the stopper is then replaced under water, the agitation renewed, and these operations are alternately performed, till no farther diminution takes place; the tube is then withdrawn, while the neck of the bottle is under water, and after the tube has been kept in this situation for a few minutes, the quantity of the diminution will be seen by the graduated scale upon the tube.

Tubes fitted up for exploding a mixture of hydrogen or other inflammable gases with oxygen gas, have been called the eudiometers of Volta; they are usually made very strong, and are provided with two wires, which pass through sockets cemented in holes drilled through the glass, near the top, which is not perforated. The electric spark being passed between these wires gives fire to the gases, not without some risk of blowing out the confined liquid, or breaking the glass.

EVEN *number*, in arithmetic, that which can be divided into two equal parts: such are 4, 10, 40, &c. A number is said to be evenly even, when, being even itself, it is measured by an even one an even number of times: such is 32, as being measured by the even number 8, an even number of times 4. Evenly odd number is, that which an even number doth measure by an odd one; such is 30, which 2 or 6, both even numbers, do measure by 15 or 5, odd ones.

EVERGREEN, in gardening, a species of perennials, which continue their verdure, leaves, &c. all the year: such are hollies, phillyrias, laurustinus, bays, pines, firs, cedars of Lebanon, &c.

EVERLASTING *pea*, the name of a perennial plant of the vetch kind, which grows naturally in some places, is easily

cultivated, annually yields plenty of excellent provender, and may be cultivated to advantage as green food for cattle, on almost any strong soil.

EVES *droppers*, or EAVES *droppers*, persons who listen under walls or windows, or the eaves of a house, by night or day, to hear news, and carry them to others, to cause strife among neighbours; and who may be presented at the leet, or bound to their good behaviour, and punished by stat. Westminster, 1. c. 33.

EUGENIA, in botany, so named in honour of Prince Eugene of Savoy, a genus of the Icosandria Monogynia class and order. Natural order of Hesperideæ. Myrti, Jussieu. Essential character: calyx four-parted, superior; petals four; drupe one-seeded, four-cornered. There are eleven species. These are trees or shrubs, all natives of the East or West Indies. The flowers are borne on peduncles, proceeding either from the axils or ends of the branches, singly, or many together, in a trichotomous structure.

EVIDENCE, in law, proof, by testimony of witnesses on oath, or by writings, or records adduced before a court, or magistrate of competent jurisdiction. It is two-fold, either written or verbal; the former by records, deeds, bonds, or other written documents, the latter by witnesses examined *viva voce*, and called, technically, parole evidence. It is also either absolute or presumptive; and may be that which is given in proof by the parties, or which the jury know of themselves, for every thing which makes a fact or thing evident to them, is called evidence.

The system of evidence adopted in British courts is very comprehensive and refined. The first rule is, that the affirmative of the issue, or matter brought in question by the proceedings, shall be proved; for a negative, generally speaking, cannot be proved, at least without such circuity as renders it almost impossible. Where a man is charged with not doing an act which by law he is required to do; however, this requires some exception; but, even then, some evidence is given to prove it. No evidence not relating to the issue, or in some manner connected with it, can be received: nor can the character of either party, unless put in issue by the very proceeding itself, be called in question. The most general and fundamental principle is, that the best evidence the nature of the cause will admit shall be produced; for if better evidence might have been adduced, its being withheld furnishes a suspicion adverse to the party in whose power it was to produce it. So that of a written contract in the custody of the party, no parole evidence can be received as to its contents. But if a deed be burnt, or destroyed by accident, upon positive proof of that fact, other evidence may be given of its contents, and it need not be produced.

Witnesses are summoned by writ of subpœna to attend, on penalty of 100*l.* to the King, and 10*l.* to the party, by statute 5 Eliz. c. 9. besides damages sustained by their non-attendance. All witnesses, of all religions, who believe in a future state of rewards and punishments, are received, but not persons infamous in law by their crimes, nor persons directly interested in the matter in issue; and no counsel or attorney shall be compelled to disclose the secrets intrusted to him by his client, but he may give evidence of facts which he knew, by other means than for the purpose of the cause. One witness is sufficient to any fact, except in high treason, when by statutes 1 Edw. VI. c. 12, and 5 and 6 Edw VI. c. 11, two are required, but that is only in treasons of conspiracy against the state, and not treasons relating to the coin, &c. The oath of the witness is, to speak the truth, the whole truth, and nothing but the truth; and all evidence is to be given in open court.

The general rules of evidence are, 1. The best evidence must be given that the nature of the thing is capable of. 2. No person interested in the question can be a witness: but to this there are exceptions; as first, in criminal prosecutions; secondly, for general usage, for convenience of trade, as a servant to prove the delivery of goods, though it tends to clear himself of neglect. 3. Where the witness acquires the interest by his own act, after the party who calls him has a right to his evidence. The third rule is, that hearsay of a matter of fact is no evidence; but of matter of reputation, such as a custom, it is in some sort evidence. 4. Where a general character is the matter in issue, particular facts may be received in evidence, but not where it occurs incidentally. 5. In every issue the affirmative is to be proved. 6. No evidence need be given of what is agreed, or not denied, upon the pleadings.

In criminal cases the same rules prevail, but evidence of the confessions of the party should be received with caution, and are rejected, when obtained through promises or threats. Presumptive evidence should be admitted with caution, and two excellent rules are given by Sir Matthew

Hale, that no one should be convicted of stealing goods of a person actually unknown, unless there is proof of a felony actually committed; and none tried for murder, until the murdered body be found.

Written evidence has been divided into two classes: the one, that which is public, the other private; and this first has been subdivided into matters of record, and others of an inferior nature. The memorials of the legislature, such as acts of parliament, and other proceedings of the two houses, where acting in a legislative character, and judgment of the King's superior courts of justice, are denominated records, and are so respected by the law, that no evidence whatsoever can be received in contradiction of them; but these are not permitted to be removed from place to place, to serve a private purpose, and are therefore proved by copies of them, which, in the absence of the original, is the next best evidence.

A bill in Chancery has been admitted as slight evidence against the complainant; and an answer is evidence against the defendant in equity himself, though not against others, and the whole may be read by the adverse party. Depositions in Chancery may be evidence at law, but not against others, and regularly not if the witness be alive, except when taken in *perpetuam rei memoriam*, &c. Matter in law ought not to be given in evidence upon a trial, but only of fact.

Of persons competent to give evidence. The King cannot be a witness under his sign manual, and a peer must be sworn to give evidence. A judge, or juror, may give evidence, the one going off the bench, and the other stating his evidence in open court. Members of corporations cannot be heard in a cause for the corporation. In actions against churchwardens, &c. for money mispent, in indictments for repair of roads, and penal actions for the benefit of the parish, parishioners may be witnesses. Kinsmen are not to be objected to. Husband and wife are not received as witnesses for or against each other, and the bail cannot be a witness for his principal, on account of his direct interest in the event. One that has any benefit under a will, or deed, must release it, before he can psove it as a witness; and by stat. 25 Geo. II. c. 6., any devise to a person who is witness to a will, or codicil, is void, and he shall be received as a witness. A bare trustee, it is said, may prove a deed made to himself. In actions for penalties on usury, the borrower, after he has paid the money, may be a witness to prove it, and in actions against the hundred, &c. the party is received as a witness in his own cause. Persons not of sound memory, attainted of præmunire or conspiracy, convicted of felony, perjury, or other infamous crimes, are incompetent to be received as witnesses; but these are restored to competency by the King's pardon, and the witness shall not be asked any question to accuse himself, but it must be proved by producing the conviction; but upon conviction of perjury, under stat. 5 Eliz. c. 9, nothing but a reversal of judgment can restore a man to competency.

Wills of land must be attested and subscribed in the presence of the testator by three witnesses. In general, the courts are inclined to favour the receiving of evidence, and to consider objections as to interest to go more to the credibility of the witness than to his competency.

A conviction of treason, of felony, and every species of infamous crime, as perjury, conspiracy, barratry, &c. prevent a man, when convicted of them, from being examined in a court of justice. When a man is convicted of any of the offences before mentioned, and judgment entered up, he is for ever after incompetent to give evidence, unless the stigma be removed, which, in case of a conviction of perjury, on the stat. of 5 Eliz. c. 9, can never be by any means short of a reversal of the judgment, for the statute has in this case made his incompetency part of his punishment; but if a man be convicted of perjury, or any other offence at the common law, and the King pardons him in particular, or grants a general pardon to all such convicts, this restores him to his credit, and the judgment no longer forms an objection to his testimony; but an actual pardon must be shewn under the great seal, the warrant for it under the King's sign manual not being sufficient to found this objection to the testimony of a witness, the party, who intends to make it, should be prepared with a copy of the judgment regularly entered upon the verdict of conviction, for until such judgment be entered, the witness is not deprived of his legal privileges.

On the question, how far persons who have been defrauded of securities, or injured by a perjury or other crime, can be witness in prosecuting for those offences, the event of which might possibly exonerate them from the obligation they are charged to have entered into, or re-

store to them money which they have been obliged to pay; the general principle now established is this, the question in a criminal prosecution on personal act being the same with that in a civil cause in which the witnesses are interested, goes generally to the credit, unless the judgment, in the prosecution where they are witnesses, can be given in evidence in this cause wherein they are interested. But though this is the general rule, an exception to it seems to be established in the case of forgery; for many cases have been decided, that a person, whose hand writing has been forged to an instrument, whereby, if good, he would be charged with a sum of money, or one who has paid money, in consequence of such forgery, cannot be a witness on the indictment.

When a witness is not liable to any legal objection, he is first examined by the counsel for the party on whose behalf he comes to give evidence, which is called his examination in chief, who is not to put what are called leading questions, *viz.* to form them in such a way, as would instruct the witness in the answers he is to give. He is then cross-examined by the other side, when leading questions are necessarily put; and then he is re-examined as to what he has been asked in his cross-examination.

The party examined must depose those facts only of which he has an immediate knowledge and recollection; he may refresh his memory with notes taken by himself at the time, and if he can then speak positively as to his recollection, it is sufficient; but if he have no recollection further than finding the entry in his book, the book itself must be produced. Deeds, receipts, and writings requiring stamps, must be stamped before they can be received in evidence.

Parole evidence shall not be admitted to annul or substantially vary a written instrument, nor to explain the meaning of a testator in a will, though, where there are two persons of the same name, and it is doubtful which is the devisee from an imperfect description, it must be proved by witnesses which is the devisee. By the statute of frauds, several things must be evidenced by writing, which previously might be proved by parole only. See FRAUDS.

The general rule has been for the last century, under the ablest judges, that no man shall be asked a question, the answer to which might subject him to criminal punishment or pecuniary penalty. It has been lately attempted by some judges to extend it further, to prevent any question being asked which may degrade a man's character, which it is feared will deprive the parties of all the substantial benefits of cross-examination. By stat. 47. Geo. III. made on the spur of a particular occasion, and to serve a party purpose on the trial of Lord Melville, a witness cannot object to answer a question, which may by the answer render him liable to an action at the suit of another party.

EULER (LEONARD,) in biography, one of the most extraordinary, and even prodigious, mathematical geniuses that the world ever produced. He was a native of Basil, and was born April 15, 1707. The years of his infancy were passed at Richen, where his father was minister. He was afterwards sent to the university of Basil; and as his memory was prodigious and his application regular, he performed his academical tasks with great rapidity; and all the time that he saved by this was consecrated to the study of mathematics, which soon became his favourite science. The early progress he made in this study added fresh ardour to his application, by which, too, he obtained a distinguished place in the attention and esteem of Professor John Bernoulli, who was then one of the chief mathematicians in Europe.

In 1723, M. Euler took his degree as master of arts, and delivered on that occasion a Latin discourse, in which he drew a comparison between the philosophy of Newton and the Cartesian system, which was received with the greatest applause. At his father's desire he next applied himself to the study of theology and the oriental languages; and though these studies were foreign to his predominant propensity, his success was considerable even in this line. However, with his father's consent, he afterwards returned to mathematics as his principal object. In continuing to avail himself of the councils and instructions of M. Bernoulli, he contracted an intimate friendship with his two sons, Nicholas and Daniel; and it was chiefly in consequence of these connections, that he afterwards became the principal ornament of the philosophical world.

The project of erecting an academy at Petersburgh, which had been formed by Peter the Great, was executed by Catharine the First: and the two young

Bernoullis being invited to Petersburgh in 1725, promised Euler, who was desirous of following them, that they would use their endeavours to procure for him an advantageous settlement in that city. In the mean time, by their advice, he made close application to the study of philosophy, to which he made happy applications of his mathematical knowledge, in a dissertation on the nature and propagation of sound, and an answer to a prize question concerning the masting of ships; to which the Academy of Sciences adjudged the *accessit*, or second rank, in the year 1727. From this latter discourse, and other circumstances, it appears that Euler had very early embarked in the curious and useful study of naval architecture, which he afterwards enriched with so many valuable discoveries. The study of mathematics and philosophy, however, did not solely engage his attention, as he, in the mean time, attended the medical and botanical lectures of the professors at Basil.

Euler's merit would have given him an easy admission to honourable preferment, either in the magistracy or university of his native city, if both civil and academical honours had not been there distributed by lot. The lot being against him in a certain promotion, he left his country, set out for Petersburgh, and was made joint professor with his countrymen, Herman and Daniel Bernoulli, in the university of that city.

At his first setting out in his new career, he enriched the academical collection with many memoirs, which excited a noble emulation between him and the Bernoullis; an emulation that always continued, without either degenerating into a selfish jealousy, or producing the least alteration in their friendship. It was at this time that he carried to new degrees of perfection the integral calculus, invented the calculation by sines, reduced analytical operations to a greater simplicity, and thus was enabled to throw new light on all the parts of mathematical science.

In 1730 M. Euler was promoted to the professorship of natural philosophy; and in 1733 he succeeded his friend D. Bernoulli in the mathematical chair. In 1735, a problem was proposed by the Academy, which required expedition, and for the calculation of which some eminent mathematicians had demanded the space of some months. The problem was undertaken by Euler, who completed the calculation in three days, to the astonishment of the Academy: but the violent and laborious efforts it cost him threw him into a fever, which endangered his life, and deprived him of the use of his right eye, which afterwards brought on a total blindness.

The Academy of Sciences at Paris, which in 1738 had adjudged the prize to his memoir concerning the Nature and Properties of Fire, proposed for the year 1740, the important subject of the tides of the sea; a problem whose solution comprehended the theory of the solar system, and required the most arduous calculations. Euler's solution of this question was adjudged a masterpiece of analysis and geometry; and it was more honourable for him to share the academical prize with such illustrious competitors as Colin Maclaurin and Daniel Bernoulli, than to have carried it away from rivals of less magnitude. Seldom, if ever, did such a brilliant competition adorn the annals of the Academy; and perhaps no subject, proposed by that learned body, was ever treated with such force of genius and accuracy of investigation, as that which here displayed the philosophical powers of that extraordinary triumvirate.

In the year 1741, M. Euler was invited to Berlin, to direct and assist the Academy that was there rising into fame. On this occasion he enriched the last volume of the Miscellanies (*Melanges*) of Berlin with five memoirs, which form an eminent, perhaps the principal figure in that collection. These were followed, with amazing rapidity, by a great number of important researches, which are dispersed through the memoirs of the Prussian Academy: a volume of which has been regularly published every year since its establishment in 1744. The labours of Euler will appear more especially astonishing, when it is considered, that, while he was enriching the Academy of Berlin with a profusion of memoirs on the deepest parts of mathematical science, containing always some new points of view, often sublime truths, and sometimes discoveries of great importance, he still continued his philosophical contributions to the Petersburgh Academy, whose memoirs display the surprising fecundity of his genius, and which granted him a pension in 1742.

It was with great difficulty that this extraordinary man, 1766, obtained permission from the King of Prussia to return to Petersburgh, where he wished to pass the remainder of his days. Soon

after his return, which was graciously rewarded by the munificence of Catharine the Second, he was seized with a violent disorder, which ended in the total loss of his sight. A cataract formed in his left eye, which had been essentially damaged by the loss of the other eye, and a too close application to study, deprived him entirely of the use of that organ. It was in this distressing situation that he dictated to his servant, a tailor's apprentice, who was absolutely devoid of mathematical knowledge, his elements of algebra, which, by their intrinsic merit in point of perspicuity and method, and the unhappy circumstances in which they were composed, have equally excited wonder and applause. This work, though purely elementary, plainly discovers the proofs of an inventive genius; and it is perhaps here alone that we meet with a complete theory of the analysis of Diophantus.

About this time M. Euler was honoured by the Academy of Sciences at Paris with the place of one of the foreign members of that learned body; after which the academical prize was adjudged to three of his memoirs, "concerning the inequalities in the motions of the planets." The two prize questions proposed by the same academy, for 1770 and 1772, were designed to obtain from the labours of astronomers a more perfect theory of the moon. M. Euler, assisted by his eldest son, was a competitor for these prizes, and obtained them both. In this last memoir, he reserved for farther consideration several inequalities of the moon's motion, which he would not determine in his first theory, on acccount of the complicated calculations in which the method he then employed had engaged him. He afterward revised his whole theory, with the assistance of his son, and Messrs. Krafft and Lexell, and pursued his researches till he had constructed the new tables, which appeared, together with the great work, 1772. Instead of confining himself, as before, to the fruitless integration of three differential equations of the second degree, which are furnished by mathematical principles, he reduced them to the three ordinates, which determine the place of the moon: he divided into classes all the inequalities of that planet, as far as they depend either on the elongation of the sun and moon, or upon the eccentricity, or the parallax, or the inclination of the lunar orbit. All these means of investigation, employed with such art and dexterity as would only be expected from a genius of the first order, were attended with the greatest success; and it is impossible to observe, without admiration, such immense calculations on the one hand, and on the other the ingenious methods employed by this great man to abridge them, and to facilitate their application to the real motion of the moon. But this admiration will become astonishment, when we consider at what period, and in what circumstances, all this was effected. It was when our author was totally blind, and consequently obliged to arrange all his computations by the sole powers of his memory, and of his genius: it was when he was embarrassed in his domestic affairs by a dreadful fire, that had consumed great part of his property, and forced him to quit a ruined house, every corner of which was known to him by habit, which in some measure supplied the want of sight. It was in these circumstances that Euler composed a work, which alone was sufficient to render his name immortal.

Some time after this, the famous occulist Wenzell, by couching the cataract, restored our author to sight; but the joy produced by this operation was of short duration. Some instances of negligence on the part of his surgeons, and his own impatience to use an organ, whose cure was not completely finished, deprived him a second time, and for ever, of his sight: a relapse which was also accompanied with tormenting pain. With the assistance of his sons, however, and of Messrs. Krafft and Lexell, he continued his labours: neither the infirmities of old age, nor the loss of his sight, could quell the ardour of his genius. He had engaged to furnish the academy of Petersburgh with as many memoirs as would be sufficient to complete its acts for twenty years after his death. In the space of seven years he transmitted to the academy above seventy memoirs, and above two hundred more, left behind him, were revised and completed by a friend. Such of these memoirs as were of ancient date were separated from the rest, and form a collection that was published in the year 1783, under the title of "Analytical Works."

The general knowledge of our author was more extensive than could well be expected in one who had pursued, with such unremitting ardour, mathematics and astronomy as his favourite studies. He had made a very considerable progress in medical, botanical, and chemical science. What was still more extraordinary, he was an excellent scholar, and

possessed in a high degree what is generally called erudition. He had attentively read the most eminent writers of ancient Rome; the civil and literary history of all ages and of all nations was familiar to him; and foreigners, who were only acquainted with his works, were astonished to find, in the conversation of a man, whose long life seemed solely occupied in mathematical and physical researches and discoveries, such an extensive acquaintance with the most interesting branches of literature. In this respect, no doubt, he was much indebted to a very uncommon memory, which seemed to retain every idea that was conveyed to it, either from reading or from meditation. He would repeat the Æneid of Virgil, from the beginning to the end, without hesitation, and indicate the first and last line of every page of the edition he used.

Several attacks of a vertigo, in the beginning of September, 1783, which did not prevent his computing the motions of the aerostatic globes, were, however, the forerunners of his mild passage out of this life. While he was amusing himself at tea with one of his grand children, he was struck with an apoplexy, which terminated his illustrious career at seventy-six years of age.

M. Euler's constitution was uncommonly strong and vigorous. His health was good, and the evening of his long life was calm and serene, sweetened by the fame that follows genius, the public esteem and respect, that are never withheld from exemplary virtue, and several domestic comforts, which he was capable of feeling, and therefore deserved to enjoy.

The catalogue of his works has been printed in fifty pages, fourteen of which contain the manuscript works. The printed ones consist of works published separately, and works to be found in the memoirs of several academies, *viz.* in thirty-eight volumes of the Petersburgh acts, (from six to ten papers in each volume;) in several volumes of the Paris acts; in twenty-six volumes of the Berlin acts, (about five papers to each volume;) in the Acta Eruditorum, in two volumes; in the Miscellanea Taurinensia, in vol. ix. of the Society of Ulyssingue; in the Ephemerides of Berlin; in the Memoires de la Société Oeconomique, for 1766.

EVOLUTE, in the higher geometry, a curve, which, by being gradually opened, describes another curve. Such is the curve B C F; (Plate V. Miscel. fig. 7.) for if a thread, F C M, be wrapped about, or applied to the said curve, and then unwound again, the point M, thereof, will describe another curve, A M M, called by M. Huygens, a curve described from evolution. The part of the thread, M C, is called the radius of the evolute, or of the osculatory circle described on the centre, C, with the radius, M C.

Hence, 1. When the point, B, falls in A, the radius of the evolute, M C, is equal to the arch, B C; but if not, to A B, and the arch B C. 2. The radius of the evolute, C M, is perpendicular to the curve, A M. 3. Because the radius, M C, of the evolute continually touches it, it is evident, from its generation, that it may be described through innumerable points, if the tangents in the parts of the evolute are produced until they become equal to their corresponding arches. 4. The evolute of the common parabola is a parabola of the second kind, whose parameter is $\frac{27}{16}$ of the common one. 5. The evolute of a cycloid is another cycloid equal and similar to it. 6. All the arches of evolute curves are rectifiable, if the radii of the evolute can be expressed geometrically.

EVOLUTION. See ALGEBRA.

EVOLUTION, in the art of war, the motion made by a body of troops, when they are obliged to change their form and disposition, in order to preserve a post, or occupy another, to attack an enemy with more advantage, or to be in a condition of defending themselves the better. It consists in doublings, counter-marches, conversions, &c. A battalion doubles the ranks, when attacked in front or rear, to prevent its being flanked, or surrounded; for then a battalion fights with a larger front. The files are doubled, either to accommodate themselves to the necessity of a narrow ground, or to resist an enemy which attacks them in flank; but if the ground will allow it, conversion is much preferable, because, after conversion, the battallion is in its first form, and opposes the file leaders, which are generally the best men, to the enemy; and likewise, because doubling the files in a new or not well disciplined regiment, they may happen to fall into disorder.

EVOLVULUS, in botany, a genus of the Pentandria Tetragynia class and order. Natural order of Campanaceæ. Convolvuli, Jussieu. Essential character: calyx five-leaved; corolla five-cleft, rotate; capsule three-celled; seeds solitary. There are seven species, all natives of the East or West Indies.

EUONYMUS, in botany, English *spin-*

dle-tree, a genus of the Pentandria Monogynia class and order. Natural order of Dumosæ. Rhamni, Jussieu. Essential character: calyx five-petalled; capsule five-sided, five-celled, five-valved, coloured, seeds calyptred, or veiled. There are eight species. These are trees or shrubs; the smaller branches or twigs four-cornered; the leaves opposite; peduncles axillary, solitary, opposite, one-flowered, sometimes many flowered, disposed in umbels.

EUPAREA, in botany, a genus of the Pentandria Monogynia class and order. Essential character: calyx five-leaved; corolla five or twelve petalled; berry superior, one-celled; seeds very many, adhering to a free receptacle. There is only one species, *viz.* E. amoena, a native of New Holland, and Terra del Fuego.

EUPATORIUM, in botany, English *hemp agrimony*, a genus of the Syngenesia Polygamia Æqualis class and order. Natural order of Compositæ Discoideæ. Corymbiferæ, Jussieu. Essential character: calyx imbricate, oblong; style cloven half way, long; down, plumose; receptacle naked. There are forty-nine species. The species native in the United States are twenty-six in number, of which the E. perfoliatum, or bone set, is a valuable medicine. These are mostly tall, growing, perennial, herbaceous plants. The greater part are natives of North America; many, however, from South America and the West Indies; several are found wild in the East Indies, and one only in Europe.

EUPHEMISM, in rhetoric, a figure which expresses things, in themselves disagreeable and shocking, in terms implying the contrary quality: thus, the Pontus, or Black Sea, having the epithet *αξενος*, *i. e.* inhospitable, given it, by reason of the savage cruelty of those who inhabited the neighbouring countries, this name, by Euphemism, was changed into that of Euxinus. In which signification nobody will deny its being a species of irony: but every euphemism is not irony, for we sometimes use improper and soft terms in the same sense with the proper and harsh.

EUPHONY, in grammar, an easiness, smoothness, and elegance in pronunciation. Euphony is properly a figure, whereby we suppress a letter, that is too harsh, and convert it into a smoother, contrary to the ordinary rules: of this there are abundance of examples, in all languages.

EUPHORBIA, in botany, English *euphorbium spurge*, a genus of the Dodecandria Trigynia class and order. Natural order of Tricoccæ. Euphorbiæ, Jussieu. Essential character: corolla four or five petalled, placed on the calyx; calyx one-leafed, bellying; capsule tricoccous. There are ninety-eight species. These are milky plants, mostly herbaceous, a few shrubby, upright for the most part, very few of them creeping; some are leafless; stems angular or tubercled, or more frequently cylindric or columnar; unarmed, or in the angular sorts resembling the upright cactuses; armed with prickles, which are either solitary or in pairs, placed in a single row on the top of the ridges.

EUPHRASIA, in botany, English *eye-bright*, a genus of the Didynamia Angiospermia class and order. Natural order of Personatæ. Pediculares, Jussieu. Essential character: calyx four-cleft, cylindric; capsule two-celled, ovate, oblong: lower anthers have a little thorn at the base of one of the lobes. There are nine species.

EURYA, in botany, a genus of the Dodecandria Monogynia class and order. Essential character: calyx five-leaved, calycled; corolla five-petalled; stamina thirteen; capsule five-celled. There is but one species, *viz.* E. Japonica, a native of Japan.

EURYANDRA, in botany, a genus of the Polyandria Trigynia class and order. Natural order of Coadunatæ. Magnoliæ, Jussieu. Essential character: calyx five-leaved; corolla three-petalled; filament much dilated at the tip, with twin disjoined anthers; folicles three. There is only one species, *viz.* E. scandens, a native of New Caledonia.

EUSTACHIAN *tube*, in anatomy, begins from the interior extremity of the tympanum, and runs forward and inwards in a bony canal, which terminates with a portion of the temporal bone. See ANATOMY.

EUSTEPHIA, in botany, a genus of the Hexandria Monogynia class and order. Corolla superior, tubular, cylindrical, bifid; nectary six cavities in the tube of the corolla; filaments tricuspidate, distinct. There is but a single species, *viz.* the coccinea.

EUSTYLE, in architecture, a sort of building in which the pillars are placed at the most convenient distance one from another, the intercolumniations being just two diameters and a quarter of the column, except those in the middle of the

face, before and behind, which are three diameters distant.

EWRY, in the British customs, an officer in the king's household, which has the care of the table linen, of laying the cloth, and serving up water, in silver ewers, after dinner.

EXAGGERATION, in rhetoric, a kind of hyperbole, whereby things are augmented or amplified, by saying more than the truth, either as to good or bad. There are two kinds of exaggeration, the one of things, the other of words. The first is produced, 1. By a multitude of definitions. 2. By a multitude of adjuncts. 3. By a detail of causes and effects. 4. By an enumeration of consequences. 5. By comparisons. And, 6. By the contrast of epithets and rational inference.

Exaggeration by words is effected, 1. By using metaphors. 2. By hyperboles. 3. By synonymous terms. 4. By a collection of splendid and magnificent expressions. 5. By periphrasis. 6. By repetition. And lastly, by confirmation with an oath; as for example, "Parietes, medius fidius, gratias tibi agere gestiunt."

EXACUM, in botany, a genus of the Tetrandria Monogynia class and order. Natural order of Rotaceæ. Gentianæ, Jussieu. Essential character: calyx four-leaved; corolla salver-shaped, with an inflated tube; capsule two-furrowed, two-celled, many-seeded, bursting at the top. There are ten species.

EXANTHEMA, among physicians, denotes any kind of efflorescence or eruption, as the measles, purple spots in the plague, or malignant fevers, &c.

According to Dr. Cullen, it is an order in the class pyrexiæ, and includes all contagious diseases, beginning with fever, and followed by an eruption on the skin.

EXCELLENCY, a title anciently given to kings and emperors, but now to embassadors, and other persons, who are not qualified for that of highness, and yet are to be elevated above the other inferior dignities. In England and France the title is now peculiar to embassadors, but very common in Germany and Italy. Those it was first appropriated to were the princes of the blood of the several royal houses; but they quitted it for that of highness, upon several great lords assuming excellency.

EXCENTRIC, in geometry, a term applied to circles and spheres which have not the same centre, and consequently aae not parallel; in opposition to concentric, where they are parallel, having one common centre.

Excentric *circle*, in the Ptolemaic system, the very orbit of the planet itself, which it was supposed to describe about the earth.

Excentric *circle*, in the new astronomy, a circle described from the centre of the orbit of the planet, with half the axis as a radius.

Excentric *place of a planet*, is the very point of the orbit, where the circle of inclination coming from the place of a planet in its orbit, falls thereon with right angles.

EXCENTRICITY, in astronomy, is the distance of the centre of the orbit of a planet from the centre of the sun, that is, the distance between the centre of the ellipsis and the focus. See Astronomy *table*.

EXCEPTION *to evidence*, at common law, is the same as a bill of exceptions, which is a formal exception made in writing, to be signed by the judge, when any evidence is improperly refused or received, and is a record of such matter, which the judge is afterwards called upon to acknowledge in court, and then being made part of the record, it is argued in the same manner as any other point of error appearing upon the record. This proceeding is founded on the Stat. of Westminster, 2.

Exception, in law, is a clause, whereby the party contracting excepts, or takes a particular thing out of a general thing granted or conveyed, and it must be something which is not inseparable from it. It must not be the whole thing granted, but part thereof only, and must be conformable, and not repugnant, to the grant, for then the exception is void. It must also be described with certainty.

EXCHANGE, in political economy. The reciprocal payments of merchants are made in bills of exchange, the amount of which is expressed in the money of the country upon which they are drawn. In calculating the par of exchange, the coin of different countries is supposed to contain that quantity of gold or silver, of a determinate purity, which, agreeably to the regulations of their respective mints, it ought to contain. Thus, an English guinea is supposed to contain 5 dwt. 6 gr. troy of gold, and a Spanish dollar 17 dwt. 6 gr. of silver each, of a certain degree of fineness.

When a bill of exchange upon Lisbon can be procured in London for the same

weight of gold or silver which the sum of Portuguese money for which it is drawn is supposed to contain, exchange between London and Lisbon is said to be at par; when it can be procured for less, exchange is said to be below par, or in favour of London; when more must be given, exchange is said to be above par, or against London.

The value of all the bills of exchange, which the merchants of London can draw upon the merchants of any other place, must in general be regulated by the value of the consignments and remittances, direct or indirect, through other countries, which they have made to that place, and consequently the course of exchange affords an indication of the state of the trade between different countries. When bills upon Lisbon, for instance, are scarce in London, and exchange consequently above par, it is a sign that London owes more to Lisbon, than Lisbon to London: and the reverse is a sign of the contrary.

But there are other circumstances by which the course of exchange is very materially affected. Should the circulating coin of any country, *v. g.* be considerably debased, and its real value, the quantity of gold or silver which it really contains, be much less than its nominal value, exchange may appear to be against a country, while actually it is in favour of it. Before the reformation of our silver coinage in the reign of William III. we are informed by Dr. Smith, the exchange between England and Holland, computed by the standard of their respective mints, was 25 per cent. against England; but the current coin of England was at that time rather more than 25 per cent. below its standard value, and consequently exchange was really in favour of England. The issue of assignats, during the revolution, depreciated the currency of France in a greater degree than was ever known in any other instance; and accordingly the exchange between London and Paris became between 60 and 70 per cent. against the latter place

An unfavourable state of the exchange with any country furnishes a motive for exporting commodities to it. The merchant, under these circumstances, can afford to sell his commodities as much cheaper as the premium which he is obliged to pay for a bill of exchange amounts to. Hence the course of exchange always tends to an equilibrium. Indeed it can never really exceed the expense of sending gold or silver bullion to the place upon which the bill is drawn: since this is the money of the commercial world, and will every where be accepted in payment. Its apparent rise above this expense is to be ascribed to a depreciation of the currency, or some similar cause. We shall now enter more into the practical part of exchange.

In treating this subject, we shall first give an idea of the nature of exchanges; and in the second place, we propose explaining the peculiar terms in use among merchants relative to bills.

In transactions between a buyer and seller, both residing in the same place, it is obvious that the mode of payment is extremely simple. It takes place either in cash or by bill, and is attended with no intricacy of computation. Transactions between two towns in the same country are almost equally easy. Payment in cash is out of the question, but the seller either draws on the buyer a bill payable at the residence of the buyer, or, if this residence is not a town of extensive trade, the buyer domiciles his acceptance at a place of this description; that is, he makes it payable there. The simplicity of this process arises from the money being of the same denomination in both places, and nearly of the same value. But in dealing with foreign countries, the calculation becomes less simple from the difference of denomination; and although this causes no real difference in the value of money, yet obstacles exist to the conveyance of specie, which almost always prevent money from being of equal value in two different countries at the same time.

Among merchants resident in different countries, bills serve nearly the same purpose as cash to the inhabitants of the same town. They are the current coin, by which the buyer in one country repays the seller in another; they pass like money from hand to hand; and this facility of circulation would always make money of nearly equal value in two countries, whose exchange of merchandize should be nearly equal. But it seldom happens that the exchange of merchandize is equal; there is almost always a balance on one side or the other. Hence the fluctuations of exchange. These fluctuations are greater or less, according to the amount of the balance to be paid, and according to the expence and difficulty of conveying specie. By the expense of conveying specie, is meant the carriage and insurance; by the difficulty, is meant the hazard of evading those prohibitory regulations, which in most

countries impede its exportation. So powerful is the operation of these causes, that the exchange is often high, even between neighbouring countries; for instance, during 1793, the trade between Holland and England was completely open, insurance was low, and the voyage is known to be short, yet money was worth 10 or 12 per cent. more in England than in Holland; that is, a bill on London cost on the exchange of Amsterdam between 10 and 12 per cent. more than the intrinsic value of the money. This continued until the spring of 1794, when the King of Prussia having promised to act with vigour against the French, on condition of receiving a large subsidy, the remittance of a part of that subsidy through Amsterdam caused an immediate fall in the rate of exchange between England and Holland.

II. Having explained the origin of fluctuations in exchange, we shall next advert to the peculiar terms used in bill transactions.

Usance. This term, derived, like many of our mercantile phrases, from the Italian (uzanzia) means the customary period at which bills used to be drawn from one particular country on another. This period between Holland and England was a month. "At two usance pay to order of, &c." in such a bill means, "at two months after date pay to order, &c." Between England and Hamburgh, and between England and France, usance is also a month. Between England and Portugal or Spain, it is two months; and between England and Italy it is three months. Its length evidently increases with the distance of two countries from each other, and was regulated by the time formerly required for the conveyance of bills. In the American and West India trades, the phrase is not known, and the common term of a bill is sixty or ninety days after sight.

The word usance continues to be employed only from conformity to ancient custom; for it has no signification, which would not be equally well expressed by the more generally intelligible phrase of months or days.

Days of grace. It has been judged fit, by the legislatures of different countries, to consider the acceptance of a bill of exchange as an engagement decidedly obligatory on the acceptor. If he fail in paying it, he not only loses his credit, but the holder of the bill may, in most countries, arrest either his person or his property. The policy of these enactments is, to give free currency to bills of exchange, by satisfying the buyer or holder of a good bill that the obligation in his hands is almost as effectual as money. Having given so much power to the holder, it was thought adviseable to extend some indulgence also to the acceptor. Accordingly days of grace were allowed him, that is, it was ordered that the holder should take no measures, and not even protest an acceptance, until the expiration of certain days after the bill became due. In London three days of grace are allowed; in Amsterdam, six; in Hamburg, twelve; in Dantzic, ten; in Copenhagen, eight; in Berlin, three; in the United States, three; and a different term in many other mercantile countries.

The practice of giving days of grace is, now at least, of no real use; for every acceptor, knowing that he may avail himself of them, does not fail to do it, and it would be considered quite ridiculous in the holder of a bill to send it for payment before the end of the three days. So that when a bill is drawn at sixty days sight or date, the only effect of the days of grace is to make sixty, sixty-three.

Protest. This is the notarial act which denotes that an irregularity has taken place in regard to the bill, either that it is not accepted, or that it is not paid. In some branches of trade it is customary, in cases of non-acceptance, not to extend, but only to note, a protest. Noting a protest is said, when a notary only records the irregularity; to extend a protest, implies that he has written out on a stamp a formal statement of that irregularity.

In a case of non-acceptance, the protest gives the holder of course no power over the person on whom the bill is drawn, but it enables him in some countries to demand security from the person of whom he received it; in other countries, the holder can do little or nothing with a protest for non-acceptance; and in these cases he generally contents himself with noting a bill when acceptance is refused. In the British West India trade, for example, it is much more customary merely to note bills for non-acceptance, than to extend the protest; for it is only in particular colonies (St. Vincent, for instance) that the holder can take prompt measures to oblige the drawer to find security to him for the amount of the bill: But on refusal of payment, a protest should always be extended; otherwise the holder would, by this omission, relieve every indorser on the bill from responsibi-

lity, and have no resourse, except on the drawer. If an accepted bill is refused payment, it is a proof that the acceptor is insolvent. The holder may either proceed against the acceptor, or he may send back the bill to the last indorser, or if there be no indorser, to the drawer. The drawer, or last indorser, as the case may be, is pledged to refund the amount immediately to the holder. This mode being generally the speediest means of reimbursement, the holder always prefers it when he can obtain payment by it; but in case of the insolvency of both drawer and acceptor, the holder retains the bill, and gets what he can from the estates of both.

When the Bank of England finds that a merchant has suspended payment, their rule is to examine all the bills drawn upon him, which have been discounted by different persons at the Bank, and to send notice to these persons that the Bank expect the bills will be taken up, and the money refunded. It is disreputable not to comply as early as possible with this intimation.

Accommodation Bills. By this term are understood bills drawn, not on occasion of a real transaction, but for the purpose of affording a temporary supply of money, or accommodation to the parties. Such bills obtain currency for several reasons. It is often difficult to distinguish a real from a fictitious bill: even when a bill is considered fictitious, it will still obtain currency, as the holder of it has the double security of the drawer and acceptor. It is as valid as a real bill, the law considering only whether the holder has given value for it, and protecting him in the recovery of that value: the shortness of the term also (seldom exceeding two months, and never almost exceeding three) naturally induces persons to think, that, although the drawer and acceptor be of doubtful credit, they will not fail quite so soon; and, in the worst event, the holder has the prospect of a double chance of recovery from the estates of both parties.

In the United States of America, the Banks avowedly sanction the practice of accommodation, and discount notes which they know to be fictitious. These notes are understood to be renewable, not so much at the pleasure of the bank, as of the borrowers of the money, and the consequence has been, that the banks have lost sight of the object of their institution, and, instead of confining their loans to the anticipation of funds, for short periods, have resolved themselves into permanent loan offices. Now there can be no doubt but that a bank, like an individual, has a right to lend *its capital* to whom, and for as long a period, as it pleases; but on the other hand it is evident, that the profitable nature of the banking business consists in its lending to a greater amount than its capital. If it does not do so, its expenses will diminish its dividends below the legal interest. But how is a bank to lend more than its capital? We answer, in two ways, *first*, by lending the money of depositors, and *secondly*, by lending its credit in the shape of bank notes. This latter operation is performed by a bank's giving its promissory note, payable on demand, without interest, in exchange for the promissory note of an individual, payable in a specified time, for which the interest is charged. If, then, a bank note is kept in circulation without being presented for payment, until the note, in exchange for which it was issued, becomes due and paid, the bank has gained the interest, without any advance of capital. Now it must be plain, that the faculty of a bank to trade thus upon its credit, without the danger of stopping payment, depends upon the length of time for which it makes loans. The shorter the period at which it discounts bills and notes, the greater is the extent to which it can safely loan, in as much as the command of its resources is more within its reach. If a bank, for instance, were to limit its loans to thirty days, it would have the command of all its capital and means within that short space of time, and thus be enabled to defend itself against any run which would be likely to be made by the presentment of its notes for payment, or the drawing out of the money of the depositors. But, on the other hand, if a bank were to give its notes, payable on demand, in exchange for the notes of individuals, payable in six months, its excessive issues over and above the amount of its capital must be very limited, or it will be in danger of more immediate demands than it is able to meet, from its immediate resources. Now this has been precisely the situation of the banks in many parts of the United States. Although the notes discounted by them have been usually drawn at 60 days, (which has been the term adopted in Great Britain and America, and elsewhere, as the longest at which banks should anticipate commercial capital,) yet the implied understand-

ing that they were not to be paid, but *renewed*, when due, has virtually deprived the banks of the real command of their resources; and this has been the chief cause, why all the banks in the United States, except those of New England, were obliged to suspend specie payments in August, 1814, or soon after.

Since we have thus touched upon the suspension of specie payments by our banks, and have pointed out one of the causes thereof, it may not be amiss to pursue the subject a little further. Whilst our banks, from a general spirit of over-trading, and particularly in that kind of loan for long periods, which cannot fail to paralize the power of a banker, they were induced, either from motives of patriotism or of speculation, to make considerable loans to the government. These loans called for an issue of bank notes, the same as if they were made to individuals, and the circulation being surcharged with paper, more of these notes were returned for payment than the banks could meet, with their immediate resources. The excess occasioned by these loans to government might, it is true, have been absorbed by reversing the operation, that is, by selling the stock for the very notes with which it was purchased; but the banks, influenced in this respect by a sordid spirit of avarice, preferred the disreputable alternative of stopping payment, whilst they possessed ample means to support their credit. But this was not all. During a state of war, it was an easy matter to palliate the disgraceful measure, by representing to the public that it was one of choice, and not of necessity; but what ought to have been the course of the banks after the restoration of peace? Surely to return to the practice of correct and honourable principles, by paying their notes with the punctuality which they demand from others. So far, however, from pursuing this course, they plunged themselves deeper into disgrace and the public into distress. Considering themselves as no longer bound to the fulfilment of contracts, no longer obliged to limit the amount of their loans, they extended their purchases of government stock, and their discounts of notes, to an excess, which created a depreciation of their paper from 15 to 30 per cent.

In vain were they told, that the system pursued by them was dishonourable and ruinous. That the prices of commodities were elevated, just in the degree that bank notes were depreciated; that helpless, aged, and labouring people, who were living upon fixed incomes, or wages, were deprived by them of their property; and that a system of over-trading, ruinous to the merchant, would be the result. Still they persevered, and still would they continue to persevere, if a resolution of Congress, and the establishment of a formidable rival, the Bank of the United States, had not compelled them to recur to the moral obligation of contracts. That institution, which commenced its operations at Philadelphia on the first of January, 1817, effected an arrangement with the banks of that city, New York, Baltimore, and Richmond, for the resumption of specie payments on the 20th of February following, which engagement has been thus far complied with, (March 1817.)

During the deplorable anarchy which so long prevailed amongst the banks, a number of curious particulars were exhibited, in relation to foreign as well as domestic exchanges. The course of exchange between all the different cities, measured in paper money, showed precisely the degree of the different depreciations, and the difference in price, at different cities, of a bill upon Boston, where money was standard, was always equal to the relative degree of depreciation. Specie also bore at every place, upon an average, the same relation to paper as a bill upon Boston, and this was of itself sufficient to show, that all the talk about balance of trade was idle and deceptive.

Exchanges, *arbitration of*, are calculations, made to find through what intermediate place it will be most advantageous to draw or remit.

The person who draws a bill of exchange, is called the *drawer;* he upon whom it is drawn, the *drawee;* and if he undertake to pay the amount, he is then called the *acceptor*. The person to whose order it is to be paid, is called the *payee*, and if he appoint another to receive the money, that other is called the *indorsee*, as the payee is, with respect to him, the indorser; and any one who happens for the time to be in possession of the bill, is called the *holder* of it.

It was above stated, that the *real* exchange between two countries never can exceed the expense and risk of transporting gold and silver from one place to the other; and yet, notwithstanding the correctness of this position, most commercial people in the United States were led

into erroneous opinions from the mere appearances of things. In the year 1812, the nominal exchange in Philadelphia upon London was as low as 25 per cent. below par; and in 1815, as high as 20 per cent. above par. The cause of it was, that, in the former case, the currency of America was sound, whilst that of London was greatly depreciated; and in the latter case, the currency of Philadelphia, by the stoppage of specie payments by the banks, was depreciated vastly below that of London. From an examination into this subject, and from comparing the relative value of paper money, in both countries, with the standard, and also taking the rate of exchange upon London at Boston, where the currency continued sound, it resulted, that, during the whole of this period of *nominal* fluctuation, the *real* exchange at no time was higher or lower than the expenses, &c. of transmitting bullion.

It very often happens that bill payments take place by *indirect* channels. A Bristol merchant, purchasing grain in Holland, makes the Dutch merchant reimburse himself by drawing on a mercantile house in London or Amsterdam; or if the Dutch merchant draw on the Bristol merchant himself, he makes it a condition that the bill shall be accepted payable in London. The object of this is to give an easy currency in negociation to the bill. The Dutch merchant sells his bill on the Amsterdam exchange; where, for one man who wishes to buy a bill on Bristol, he will find twenty who wish to purchase on London. Hence, the tendency of all exchange transactions to certain central points. That point is always the principal trading city in the country. Throughout Great Britain, a bill on London is preferred to a bill on any other place; and what London is to this country, Amsterdam, in its better days, was to Europe.

Every country town in Great Britain is said to have its par of exchange on London. By this is meant the term or number of days at which the country bank will give a bill on London in exchange for cash. This term is greater or less, according to the distance from London. In Bristol it is twenty-five days, in Liverpool thirty, in Glasgow forty-five, and in the more remote parts of Scotland fifty days.

It is important to know, that a very small matter will amount to an acceptance. If the person upon whom a bill is drawn say, *verbally*, that he will accept the bill, he is not at liberty afterwards to change his mind; or if his clerk say that the bill will be accepted, it is an acceptance. But the most usual mode of acceptance is, for the acceptor to put his name upon the face of the bill, accompanied by the date of presentment, when the bill is payable at such a period after sight. The validity of an acceptance, however, being founded in different countries upon the custom of merchants, reference must be had to them for a minute detail.

Exchange signifies also a place in most considerable trading cities, wherein the merchants, negociants, agents, bankers, brokers, interpreters, and other persons concerned in commerce, meet on certain days, and at certain times thereof, to confer and treat together of matters relating to exchanges, remittances, payments, adventures, assurances, freightments, and other mercantile negociations, both by sea and land.

These assemblies are, in some countries, held with so much exactness, that the absence of a merchant, &c. makes him suspected of drawing to a failure of bankruptcy, as not being able to stand the change.

The most considerable exchanges in Europe are, those of Amsterdam, and that of London, called the Royal Exchange. See Royal Exchange.

Table of the Par of Exchange between the United States and Foreign Countries, in 1817.

	Dolls.	Cts.
Pound Sterling of Great Britain	4	44
Ireland . .	4	10
Livre Tournois of France . .		18½
Franc of France		19
Guilder or Florin of United Netherlands		39
Mark Banco of Hamburgh . .		33½
Rix Dollar of Denmark and Sweden	1	00
Mill Rea of Portugal	1	24
A Johannes	16	00
A Doubloon	14	93⅓
An English Guinea	4	66⅔
A Ruble of Russia		66
A Dollar of Spain	1	00
Rial Plate of Spain		10
Pagoda of India	1	94
Tale of China	1	48
Rupee of Bengal		55½

Exchange, in law, is a mutual grant of equal interests, the one in consideration of the other; and upon such a conveyance, no livery of seisin, even of freehold, is necessary to perfect it: for each party stands in the place of the other, and occupies his right, and each of them hath already had corporal possession of his own land. But entry must be made on both sides; for if either party die before the entry, exchange is void for want of sufficient notoriety.

Both the estates exchanged should be equal. But not equal value, but only in the kind and manner of the estate.

Exchange-*re*, is when the holder of a bill finds it not paid by the acceptor, then it becomes necessary to draw other bills upon the parties, which create exchange, and the exchange paid upon that transaction is, by the usage of merchants, chargeable upon the preceding parties to the bill, by way of re-exchange.

EXCHEQUER, from the French, *eschequier*, i. e. *abacus tabula lusoria*, is a court of law and equity, established by William the Conqueror, as a part of the *aula regis*, though regulated and reduced to its present state by Edw. I. and intended principally to order the revenue of the crown, and to recover the King's debts and duties. The court consists of two divisions, *viz.* the receipt of the exchequer, which manages the royal revenues; and the judicial, which is again subdivided into a court of equity, and a court of common law. The court of equity is held in the Exchequer, before the Lord Treasurer, the Chancellor of the Exchequer, the Chief Baron, and three puisne Barons. The primary and original business of this court was, to call the King's debtors to account, by bill filed by the Attorney General, and to recover any lands, tenements, or hereditaments, goods, chattels, or other profits, or benefits, belonging to the crown; but now, by a fiction of law, suggesting that the party is a debtor of the King, and is less able to pay his debt, unless he has the aid of the court to recover of his own debtor, any person may be admitted to sue here. An appeal from the equity side of this court lies immediately to the House of Peers; but from the common law side, pursuant to 31 Edw. III. c. 12, a writ of error must first be brought into the court of exchequer chamber, whence appeal lies to the house of Lords. The exchequer, as a court of law, is the last of the courts.

In this court suits are generally brought for tythes, although the Court of Chancery also exercises considerable jurisdiction in that respect. The Exchequer is also divided into the court for judicial business; and the other, the receipt of the Exchequer, in which the accounts of the revenue are kept, and the money is received: in this branch of the Exchequer there are several officers; such as two chamberlains, the controller of the pipe, the clerk of the estreats, the foreign opposer, the auditors, the four tellers, the clerk of the pells, clerk of the nichils, &c. By stat. 23 Geo. III. c. 82, the offices of the two chamberlains, tally-cutter, usher, and second clerks to each teller, shall, after the death of the present officers, be abolished; and instead of tallies, indented cheque receipts are to be used: also after the death of the auditor, clerks of the pells, four tellers, and two chamberlains, their fees shall be abolished, and their salaries be fixed.

Exchequer *chamber*. This court has no original jurisdiction, but is merely a court of appeal, to correct the errors of other jurisdictions, and consists of the Lord Chancellor, the Lord Treasurer, with the Justices of the King's Bench and Common Pleas. In imitation of this, a second court of Exchequer chamber was erected by 27 Eliz. c. 8, consisting of the Justices of the Common Pleas, and the Barons of the Exchequer, before whom writs of error may be brought to reverse judgments in certain suits, commenced originally in the court of King's Bench. Into the Exchequer chamber are sometimes adjourned, from the other courts, such causes, as the judges, upon argument, find to be of great weight and difficulty, before any judgment is given upon them in the court.

Exchequer, *Chancellor of*, is, in Great Britain, the officer to whom the arrangement of the financial concerns of the country is chiefly entrusted. He causes accounts to be annually laid before parliament of the produce of the taxes, with estimates of the several branches of public expenditure for the ensuing year; and if the amount of the estimated expenditure exceeds the probable produce of the revenue, he adjusts the extent and conditions of the loan with such persons as are willing to advance the same, and proposes to parliament the new taxes which become necessary for paying the interest on the money thus borrowed. On the foundation of the accounts and

estimates submitted to parliament, particular sums are voted for the several branches of the expenditure, and where the ways and means of raising the whole sum wanted have been determined, an act is passed, appropriating the specific sums to the various articles forming the supplies which have been granted. In order to provide against any unforeseen expences, it is usual to grant also a certain sum, unappropriated to any particular purpose, to be applied to any branch of the expenditure in which there may be occasion for it; this is called a vote of credit, and has increased in amount with the progress of the supplies; in the American war it was 1,000,000*l.* per annum, of late it has generally been 2,500,000*l.* Soon after the commencement of each session, an account is laid before the House of Commons, shewing how the money given for the service of the preceding year has been disposed of, and what part thereof remains unpaid. If the ways and means have fallen short of the sum they were expected to produce, the deficiency is made good as an article among the next year's supplies.

Exchequer bills, bills or tickets issued by the Exchequer, payable out of the produce of a particular tax, or generally out of the supplies granted for the year, and receivable in all payments to the exchequer. The first bills of this kind were issued in 1697, as a more convenient kind of security than the tallies and orders for repayment then in use, and were partly intended to supply the want of money during the recoinage then undertaken. With this view, many of them were made out of small sums, as low as 10*l.* and 5*l.* each; and though they bore no interest when first issued, upon being re-issued, after having been paid into the Exchequer upon any of the taxes, they carried interest at 5*d.* a day per cent. equal to 7*l.* 12*s.* 1*d.* per cent. per annum. These bills being regularly discharged, other sums soon raised on similar securities, and their credit becomiug established, they have ever since been used for anticipating the produce of particular taxes, and have almost constantly formed the principal article of that part of the public debt called the unfunded debt. Of late years, the total amount of outstanding Exchequer bills (exclusive of those charged on specific branches of the revenue) has usually been about twelve millions. The interest payable on them has been at various rates, according to the current rate of interest at the time they were issued; those at present (1808) in circulation bear interest at the rate of 3½*d.* a day per cent. They are frequently made out for 100*l.* each, but those issued of late years have been chiefly for 1000*l.* each, and they have sometimes been made for much larger sums; they are numbered arithmetically, and registered accordingly, for the purpose of paying them off in regular course, the time of which is notified by public advertisement.

The daily transactions between the Bank and the Exchequer are chiefly carried on by these bills, which are deposited by the Bank in the Exchequer, to the amount of the sums received by them on account of government; the bank notes and cash thus received by the Bank being retained by them, as the detail part of the money concerns of government is all transacted at the Bank. The instalments on loans are paid into the receipt of the Exchequer in Exchequer bills, which are received again by the Bank as cash, either for the amount of dividends due, or in repayment of advances.

When these bills sell at a considerable discount, or any other circumstance indicates that the quantity of them in circulation is too great, the usual expedient is to fund a part of them; that is, to convert them into a permanent debt, by offering the holders of them stock in lieu of their bills; this was done in October 1796, in November 1801, and again in March 1808. The total amount of Exchequer bills outstanding on the 5th of January 1807, including 3,000,000*l.* held by the Bank, pursuant to an agreement for the renewal of their charter, was 27,207,100*l.*

Exchequer, *black book of the*, a book containing a description of the court of England in 1175, and its officers, with their ranks, wages, privileges, perquisites, &c. also the revenues of the crown, both in money and cattle.

EXCISE *duties*, inland taxes on commodities of general consumption. This mode of taxation, having been always found very productive, has been adopted by all the European governments, and by some of them has been extended even to the necessaries of life; but, in general, the articles subjected to it have been such as are not absolutely essential to subsistence. Salt appears to have been the object of an excise duty at a very early period; in later times, oil, wine, tobacco, and various other con-

sumable articles, have been burthened with duties of this description.

Excise duties were first established in England in 1643, when the long parliament laid a tax on beer and ale in all the counties within their power; and the king's parliament, then sitting at Oxford, imposed the like taxes on all within their power, by which means these new duties, called excise, became general. It is supposed that the plan was originally adopted, in consequence of its success in the neighbouring commonwealth of Holland. It was at first laid upon liquors only; and it was solemnly declared, that at the end of the war all excises should be abolished; but the contest continuing longer than was expected, this obnoxious mode of levying money was extended to bread, meat, salt, and many other articles. The excise on bread and meat was afterwards repealed.

In the year 1660, two duties were imposed on English ale, amounting to 2*s.* 6*d.* per barrel of strong, and 6*d.* per barrel of small beer; a duty of 2*d.* per gallon was also imposed on home-made spirits. These duties were farmed till the year 1684, when they were put under the management of commissioners. For a considerable time they yielded a revenue that was gradually increasing, and which amounted, in the year ending midsummer 1688, to 786,915*l.* 12*s.* 7*d.* Soon after the revolution several temporary duties were imposed on beer and ale: and in 1694, the established duties were 4*s.* 9*d.* per barrel on strong, and 1*s.* 3*d.* per barrel on small beer: the augmentation of the revenue was not, however, proportionate to the increase of the duties, which was attributed by Dr. Davenant to improper management, but probably arose, in part at least, from the increased temptation to evade the duties.

Various additions to the original duties were made at subsequent periods, and the excise being extended to candles, soap, starch, hides, and other articles, it became one of the most productive branches of the public revenue; the gross produce, in the year 1732, being 2,964,617*l.* About this time Sir Robert Walpole, who was of opinion that taxes on consumable commodities, to which every citizen contributes in proportion to his consumption, and which being included in the price of the commodity, are insensibly paid, constituted the most eligible mode of raising the revenue necessary for the public service, formed a project for the gradual abolition, not only of the taxes on land, houses, and windows, but likewise the customs, by the substitution of productive excise duties. He was influenced in the formation of this scheme by a knowledge of the gross and shameless frauds then daily practised in the collection of the customs; and which, from the very nature of those frauds, and the extreme facility of committing them, he had no hope to remedy: he thought, therefore, that to convert the greater part of the customs into duties of excise, would be equally advantageous to government and to the fair trader; and that the excise laws might be so ameliorated, that, notwithstanding the odium generally attached to them as oppressive and arbitrary, no just ground of complaint should remain. With a view, therefore, to the execution of this plan, he obtained a revival of the salt duties, which had been repealed some years before; but upon proposing, in the following year, to transfer the duties on wine and tobacco to the excise, so much clamour was raised against the measure, that the minister, after some perseverance, thought it prudent to relinquish this favourite project. The defeat of this scheme was celebrated by general rejoicings, as a deliverance from the greatest political danger: had it succeeded, between four and five millions a year would have been raised under the excise system, in addition to the excise duties then subsisting: by the various duties which at different times have been since imposed, upwards of fifteen millions a year is now raised under the excise, in addition to the amount of this branch of the revenue at the above period.

The several commodities now subject to excise duties are, ale and beer, cyder, perry, mead, British and foreign spirits, wine, vinegar, verjuice, malt, hops, salt, soap, starch, candles, coffee, tea, tobacco, and snuff, bricks and tiles, glass, hides and skins, paper, printed goods, and wire. The various rates of duty which had been imposed at different times were consolidated in the year 1787, when other regulations were also adopted, by which the produce of the revenue was augmented, and the expense of collecting it materially reduced, as appears from the rate per cent. which the expenses of management amounted to in the following years.

EXCISE.

Years.	Gross Receipt. L.	Rate per cent. L.	s.	d.
1789	8,418,611	5	10	0
1790	9,054,850	5	11	0
1791	9,808,908	5	0	4
1792	10,113,867	4	19	10
1793	9,412,487	5	5	7
1794	9,964,293	5	0	4
1795	10,866,170	4	13	11
1796	10,960,425	4	12	1

The additional duties which the progress of the public expenditure has rendered it necessary to impose, have greatly increased the produce of the excise, and rendered it the most important branch of the public revenue. The duties which it comprehends are divided into the permanent consolidated duties, the temporary war taxes, and the annual duties; the latter consist of the old annual malt duty, and of an additional malt duty, which, with some duties on tobacco and snuff, and some custom duties, have, since the project for selling the land tax, been granted annually in lieu thereof.

Total gross produce of the Excise Duties in England, in the year ending the 5th of January, 1807.

	L.	s.	d.
Auctions	249,891	14	1½
Beer and ale	2,971,351	15	7¼
Bricks and tiles	306,661	10	0¼
Candles	311,449	4	8
Cocoa nuts and coffee	124,178	5	7½
Cyder and perry	19,772	5	1¾
Glass	424,786	3	9¾
Hides and skins	311,322	17	1
Hops	56,339	15	2½
Licences	301,083	17	11¼
Malt	1,388,130	8	8¼
Matheglin, or Mead	161	8	9
Paper	359,158	5	5½
Printed goods	698,373	17	8
Salt	1,470,704	13	2¾
Soap	586,564	5	7½
Spirits, British	1,201,200	19	11
Ditto, foreign	1,772,866	14	5¾
Starch	60,025	14	0¼
Sweets	24,771	0	6¼
Tea	1,280,751	16	8½
Tobacco and snuff	196,188	10	10¼
Vinegar and verjuice	38,024	14	7½
Wine	1,149,313	8	7¾
Wire	13,388	9	11
WAR TAXES.			
Wine	210,292	7	3¼
Malt	2,713,173	10	8¾
Spirits, British and foreign	1,473,936	6	11¼
Sweets	4,483	12	3¼
Tea	1,313,664	13	7¼
Tobacco and snuff	162,342	18	10½
ANNUAL DUTIES.			
Old malt duty	676,810	12	0¾
Additional malt duty	1,115,491	1	9
Tobacco and snuff	428,140	4	9¼
Total	L.23,414,796	6	7¼

The balance of cash at the commencement of the year being 27,790*l*, 3*s*. 3¾*d*. added to the above sum, makes the total to be accounted for 23,442,586*l*. 9*s*. 11*d*. This amount is subject to various deductions, consisting principally of the expenses of management, drawbacks of duty on goods exported, allowances and bounties on several commodities, annual payments to the officers of the late wine licence office and of the old salt duties, and pensions granted by patent out of the excise, while it formed part of the hereditary revenue of the crown. The amount of these payments in the year ending the 5th of January, 1807, was as follows:

	L.	*s.*	*d.*
Charges of Management	569,341	0	4¼
Taxes repaid to officers	30,513	15	8¾
Exports	920,712	3	10
Allowances	69,242	5	11¼
Bounties	20,304	19	5¼
Overcharges, overpayments, repayments, per treasury warrant, &c.	29,701	15	0¾
Payments to officers of late wine office and salt duties	10,599	4	5¼
Pensions to the Duke of Grafton and others . .	14,000	0	0
Payments into the Exchequer	21,739,067	12	10
Balance of cash remaining the 5th of January, 1807, carried to the next year's account,	39,103	12	3½
Total . . . . *L.*	23,442,586	9	11

The total gross produce of the excise duties in Scotland, in the above year was, 1,824,394*l*. 0*s*. 6½*d*.; of which the sum of 1,445,000*l*. was paid into the exchequer during the year. The total gross produce of the excise duties in Ireland, for the same year, was 1,453,500*l*. 0*s*. 2*d*.

The excise duties of England are under the management of nine commissioners, with salaries of 1200*l*. per annum each; and they are sworn to take no fee or reward but from the king only. From these commissioners there lies an appeal to five others, called commissioners of appeals. The commissioners of excise in Scotland are five in number, and have salaries of 600*l*. per annum each. The number of officers employed in collecting this branch of the revenue is very great. Besides the commissioners and their subordinate officers, as secretary, comptrollers, auditor, accomptants, registers, inspectors, and a great number of clerks in the different departments, there are 24 country examiners, 284 supervisors, 2750 gaugers, or excisemen, &c. Previous to the appointment of any person to the office of guager, he must procure a certificate of his age, which must be between 21 and 30; he must understand the four first rules of arithmetic; be of the communion of the Church of England; and, if married, not have more than two children; he must nominate two persons to be his securities: and the certificate containing these particulars, and written by himself, must be signed by the supervisor of the district where he lives, and accompanied with an affidavit that he has used no bribes for obtaining the office.

Excise, in law, is an inland imposition, sometimes paid upon the consumption of the commodity, or frequently upon the retail sale, which is the last stage previous to the consumption. For more easily levying the revenue of the excise, the kingdom of England and Wales is divided into about fifty collections, some of which are called by the names of particular counties, others by the names of great towns; where one county is divided into several collections, or where a collection comprehends the contiguous parts of several counties, every such collection is subdivided into several districts, within which there is a supervisor; and each district is again subdivided into out-rides and foot-walks, within each of which there is a guager or surveying officer.

The officers of excise are to be appointed, and may be dismissed, replaced, or altered by the commissioners, under their hands and seals; their salaries are allowed and established by the Treasury; and by 1 William and Mary, c. 24, s. 15, if it be proved by two witnesses, that any officer has demanded or taken any money, or other reward whatever, except of the

King, such offender shall forfeit his office. By several statutes, no process can be sued out against any officer of excise, for any act done in the execution of his office, until one month after notice given, specifying the cause of action, and the name and abode of the person who is to begin, and the attorney who is to conduct, the action: and within one month after such notice, the officer may tender amends, and plead such tender in bar; and having tendered insufficient or no amends, he may, with leave of the court, before issue joined, pay money into court.

Officers of excise are empowered to search at all times of the day, enter warehouses, or places for tea, coffee, &c. But private houses can only be searched upon oath of the suspicion before a commissioner or justice of peace, who can by their warrant authorise a search. The office of excise has also several excellent regulations for procuring the due attention and good conduct of their officers.

EXCITATION *of electricity*. When a non-conductor of electricity is brought into an electrified state by any other means than that of direct communication with some other electrified body, it is said to be excited; and this term is also applied to denote the like production of an electric state, even in bodies which conduct. The processes by which excitation is performed are very imperfectly understood. It is probable that they will all be hereafter found to consist in the same act; and that this will principally be governed by changes in the combination, and perhaps the temperature of bodies.

1. The electric state is produced in various bodies by heating or cooling, particularly in the tourmalin. Sulphur, chocolate, and various other substances, become electrified upon congealing or becoming solid after fusion; and it is probable that this phænomenon would be found to be universal, if proper means were adopted for ascertaining the electric states. Calomel, when it fixes by sublimation against the upper surface of a glass vessel, frequently breaks through by an electric explosion. The glacial phosphoric acid was observed by Chaptal to emit strong electric sparks, while congealing. Water and other fluids become electric by evaporation. And the chemical changes of bodies have been shewn, in numerous galvanic experiments, to be attended with corresponding changes of electricity. See GALVANISM.

2. The mechanical action of bodies upon each other produce electrical effects. If two metals or other conductors be brought into contact, and separated, or if they be pressed or rubbed together, electric signs are produced; and the same consequences follow, if one or both the bodies be non-conductors: but the electricity is more manifest where the non-conducting property prevails. When non-conductors are broken or torn asunder, the surfaces which were before in contact are found to be in opposite electric states; and this difference is so considerable in Muscovy talc, that bright sparks pass between them. From these facts, there is ground to suspect, that the opposite electric states prevail amongst the parts of bodies, and may perhaps be in some manner concerned in the general attraction they exert upon each other.

3. The electricity in our common machines is produced by the friction of a conducting body against a non-conductor. See MACHINE, *electric*.

The non-conductor may be a tube, a globe, a cylinder, or a plate of glass, and the conducting rubber is usually a cushion, upon which a mixture of the amalgam of zinc with a little tallow has been smeared. It is found to be a condition, that atmospheric air should be present; and if the electricity be taken off from the surface of the cylinder while it revolves, the cushion will not restore or supply the electric state, unless it be admitted to communicate with the earth. So that, if an insulated conductor be placed near the cylinder, it will receive electricity for a time, though the rubber be also insulated; but the rubber itself, after assuming the negative state, will soon cease to give any more electricity to the cylinder, than the little it may obtain from the imperfect nature of its insulation. But if a communicating branch from the positive conductor be brought within a short distance of the negative cushion, the positive sparks will fly through the interval, and supply the cushion; and in this manner the circulation of electricity may, as far as yet has been determined by experiment, be kept up for an unlimited time. It seems, therefore, as if a chemical process requiring atmospheric air, and therefore of the nature of combustion, were carried on at the face of the cushion, and that a peculiar substance, on which the electric state depends, becomes deposited or disposed in a different manner from that which it possessed before; and that the relative

motion of the non-conducting body carried it off to a situation where it tends to its former state, and consequently advances in a current towards such parts as allow of the restoration of that state. It seems reasonable to conclude, that the disturbances of the electric state or equilibrium, and the currents by which they are restored, are in most natural operations performed through very short and good conductors; so that, though in all probability they may contribute to very important results, the immediate changes elude our observation, except in a few instances, such as that of lightning and luminous meteors. And it seems from the facts to be nearly decided, that we should never have had it in our power to exhibit the phænomenon of the electric spark, which is electricity producing ignition by breaking through a non-conductor, if we had not fortuitously experimented in circumstances, where the electricity is first made to take the form of a charge, and afterwards brought into a state of considerable intensity, by separating those bodies from each other, which produced the compensation by their opposite states. Thus in the electrical machine, (see Nicholson, in the Philos. Trans. 1789,) little or no electric signs are produced by a cylinder rubbed by a very flat amalgamed leather, terminating in a neat line of contact. But this rubber and cylinder will, without any alteration, afford electricity, if a flat piece of metal, or the hand, or any other flat conductor, be held over that part of the cylinder which is in the act of receding from the cushion, even though this conductor be held at the distance of an inch or more, without touching either the cylinder or its rubber. It is proved from experiment, that the conducting body thus presented acquires the opposite state, and enables the cylinder to carry off a greater quantity of electricity in the form of a charge, the interposed air being the electric.

When the cushion is thick and rounded, as is the case with the human hand, which was first used for this purpose, the rounded part opposite the receding surface of the cylinder, performs the office of compensation; and the best application, which has yet been made for this purpose, is that of a flap of silk proceeding from beneath the cushion, which assumes the negative state, so as to compensate the positive state on the cylinder, in a very considerable charge, which is conveyed by the rotation to the farther end of the silk, where it becomes uncompensated electricity upon the naked surface, at an intensity which could not otherwise have been produced.

It has not been determined yet what are the conditions and circumstances of the change which takes place by the action of the air at the face of the rubber, nor why the surface of the glass should become positive when rubbed with one kind of rubber, as for example the human hand; and negative, if rubbed with another kind, such as cat-skin, or flannel; nor why glass, deprived of its polish, becomes negative with rubbers, which would have rendered smooth glass positive. The most rational conjecture seems to be, that the surface which is most heated in consequence of its roughness, or the relative smallness of its dimensions, acquires the negative state.

There is a certain velocity of rotation, which is about five feet per second, at which the excitation of electricity by a cylinder nearly vanishes; but it returns again the moment the velocity is diminished. Some, who maintain the existence of a material cause of heat, or caloric, are disposed to consider electricity as one of the states of caloric, in which the matter of heat can pass through bodies without raising their temperature, and with much greater velocity than that by which temperature is communicated.

From the imperfect knowledge we possess respecting excitation, it is very difficult for the most experienced electricians to excite a cylinder with certainty and power. If the cylinder be greased all over with tallow, and then turned for some time in contact with the cushion, the silk flap being thrown back, and an amalgamed leather be applied and rubbed about upon the surface of the cylinder in motion, electric sparks are soon produced in abundance; and if the silk be then thrown again into contact with the cylinder, the excitation will, in general, be strong; but it is seldom so strong at the first time of exciting, as it proves to be after the expiration of a day or more. It seems as if the amalgam and tallow required a considerable time of working to be brought into the best state for excitation.

In order to judge of the degree of intensity of an excited cylinder, we must have recourse to some standard of the quantity of effect produced by the friction of a given surface. It has not been shewn that much, if any thing, depends

on the thickness of the glass, though some kinds of glass are more excitable than others, and some not at all so. If a coated electric jar be taken of about one-twentieth of an inch in thickness, (see Jar, *electric*,) a cylinder or plate moderately excited, will require fifty or sixty square feet to pass the cushion, in order to charge one foot of the coated glass, so as to explode over a rim of three inches, which is as much as can be admitted without danger of the explosion breaking through the jar. If the excitation be stronger, the charge may be made by the friction of thirty feet to one of the jar; and the strongest excitation the editor has ever known has been by the friction of fourteen square feet of a cylinder to charge one foot of glass. But as the labour increases by adhesion of the cushion, the stronger the excitation, it seems as if the strength of a man would be more profitably employed in turning two or more plates, or cylinders, at the intensity of thirty feet, than at any higher intensity: besides which, this power is less variable, and may last five or six hours without requiring fresh amalgam.

The vulgar notion of electricity is, that it is fire which passes in a spark from one body to another. From its passage through dense conductors, as well as through the air, it seems to move with extreme velocity: and this may be sufficient, without supposing it to be essentially luminous, to account for the ignited appearance it affords, in all non-conductors, whether air, or oil, or glass, or wood, &c. and even in metal, when the conductor is small. If oxygen be present, these bodies will have their combustible parts burned; and if not, a decomposition of those parts which are ignited may ensue.

EXCLAMATION, in rhetoric, a figure that expresses the violent and sudden breaking out and vehemence of any passion. Such is that in the second book of Milton's "Paradise Lost:"

> "O unexpected stroke, worse than of death!
> Must I thus leave thee, Paradise? Thus leave
> Thee, native soil; these happy walks and shades,
> Fit haunt of gods!"

Other figures are the language of some particular passion, but this expresses them all. It is the voice of nature, when she is in concern and transport.

EXCLUSION, or *Bill of Exclusion*, a bill proposed about the close of the reign of King Charles II. for excluding the Duke of York, the king's brother, from the throne, on account of his being a papist.

Exclusion, in mathematics, is a method of coming at the solution of numerical problems, by previously throwing out of our consideration such numbers as are of no use in solving the question.

EXCLUSIVE is sometimes used adjectively, thus: "A patent carries with it an exclusive privilege;" and sometimes adverbially, as, "He sent him all the numbers from N° 145 to N° 247 exclusive;" that is, all between these two numbers, which themselves were excepted.

Exclusive *propositions*, in logic, are those where the predicate so agrees with its subject, as to exclude every other. Thus, "Virtue alone constitutes nobility," is an exclusive proposition.

EXCOECARIA, in botany, a genus of the Dioecia Triandria class and order. Natural order of Tricoccæ. Euphorbiæ, Jussieu. Essential character: ament naked; calyx and corolla, none; styles three; capsule, tricoccous. There are two species; *viz*. E. agallocha and E. Cochin Chinensis.

EXCOMMUNICATION, in law, is of two kinds, the less and the greater, which last is the highest ecclesiastical censure which can be pronounced; for thereby the party is excluded from the body of the church, and disabled from bringing any action in the common law courts; he is also disabled to serve on juries, or to be a witness in any cause; he cannot be attorney or procurator for another; he is to be turned out of the church by the church wardens, and not to be allowed christian burial. He may also, in some cases, be imprisoned until he submits to the ecclesiastical jurisdiction, as in case of refusing to answer to a suit for tithes.

EXCORIATION, in medicine and surgery, the galling or rubbing off of the cuticle. To remedy this, the parts affected may be washed often with warm water, and sprinkled with drying powders, as chalk, hartshorn, but especially tutty, lapis calaminaris, and ceruse, which may be tied loosely in a rag, and the powder shook out on the disordered places.

EXCREMENT. See Feces.

EXCRESCENCE, in surgery, denotes

every preternatural tumour which arises upon the skin, either in the form of a wart or tubercle.

EXCRETION, or SECRETION, in medicine, a separation of some fluid, mixed with the blood by means of the glands. See SECRETION.

EXCRETORY, in anatomy, a term applied to certain little ducts or vessels, destined for the reception of a fluid, secreted in certain glandules, and other viscera, for the excretion of it in the appropriated places.

EXECUTION, in law, is a judicial writ, grounded on the judgment of the court whence it issues; and is supposed to be granted by the court, at the request of the party at whose suit it is issued, to give him satisfaction on the judgment which he hath obtained: and therefore an execution cannot be sued out in one court, upon a judgment obtained in another. These are of different sorts, according to the nature of the action: in actions where money is recovered, as a debt or damages, they are of five sorts; 1, against the body of the defendant; 2, or against his goods or chattels; 3 against his goods and the profits of his lands; 4, against the goods and the possession of his lands; 5, against all three, his body, lands, and goods.

EXECUTION *of criminals*, must be according to the judgment; and the King cannot alter a judgment from hanging to beheading, because no execution can be warranted, unless it be pursuant to the judgment.

This being the completion of human punishment, in all cases, as well capital as otherwise, must be performed by the legal officer, the sheriff or his deputy. Murderers are to be executed the day next but one after conviction, unless it be Sunday, and anatomized; for which reason they are generally tried on a Friday.

EXECUTION, in music, a term applicable to every species of musical performance; but more particularly used to express a facility of voice or finger in running rapid divisions, and other difficult and intricate passages: it includes, in a general sense, taste, feeling, grace, and expression.

EXECUTOR, in law, is a person appointed by the testator to carry into execution his will and testament after his decease. The regular mode of appointing an executor is, by naming him expressly in the will; but any words indicating an intention of the testator to appoint an executor, will be deemed a sufficient appointment.

Any person capable of making a will is also capable of being an executor: but in some cases, persons who are incapable of making a will, may nevertheless act as executors, as infants, or married women; to obviate, however, inconveniences which have occurred respecting the former, it is enacted by stat. 38 Geo. III. c 89, that where an infant is sole executor, administration, with the will annexed, shall be granted to the guardian of such infant, or such other person as the spiritual court shall think fit, until such infant shall have attained the age of 21; when, and not before, probate of the will shall be granted him. An executor derives his authority from the will, and not from the probate, and is therefore authorised to do many acts in execution of the will, even before it is proved; such as releasing, paying, or receiving of debts, assenting to licences, &c.; but he cannot proceed at law until he have obtained probate. If an executor die before probate, administration must be taken out with the will annexed; but if an executor die, his executor will be executor to the first testator, and no fresh probate will be needed: it will be sufficient if one only of the executors prove the will; but if all refuse to prove, they cannot afterwards administer, or in any respect act as executors. If an executor become a bankrupt, the court of Chancery will appoint a receiver of the testator's effects, as it will also upon the application of a creditor, if he appear to be wasting the assets. If an executor once administer, he cannot afterwards renounce. If an executor refuse to take upon him the execution of the will, he shall lose his legacy under it. If a creditor constitute his debtor his executor, this is at law a discharge of the debt, whether the executor act or not; provided, however, there be assets sufficient to discharge the debts of the testator: in equity, however, there are some exceptions to this rule The first duty of an executor or administrator is, to bury the deceased in a suitable manner; and if the executor exceed what is necessary in this respect, it will be a waste of the substance of the testator. The next thing to be done by the executor is, to prove the will, which may be done either in the common form, by taking the oath to make due distribution, &c.; or in a more solemn mode, by witnesses to its execution. By stat. 37 Geo.

III. c. 9, s. 10, every person who shall administer the personal estate of any person dying, without proving the will of the deceased, or taking out letters of administration within six calendar months after such person's decease, shall forfeit 50*l*.

If all the goods of the deceased lie within the same jurisdiction, the probate is to be made before the ordinary or bishop of the diocese, where the deceased resided; but if he had goods and chattels to the value of 5*l*. in two distinct dioceses or jurisdictions, the will must be proved before the metropolitan or archbishop of the province in which the deceased died. An executor, by virtue of the will of the testator, has an interest in all the goods and chattels, whether real or personal, in possession or in action of the deceased; and all goods and effects coming to his hands will be the assets to make him chargeable to creditors and legatees. An executor or administrator stands personally responsible for the due discharge of his duty; if, therefore, the property of the deceased be lost, or through his wilful negligence become otherwise irrecoverable, he will be liable to make it good; and also where he retains money in his hands longer than is necessary, he will be chargeable not only with the interest, but costs, if any have been incurred.

But one executor shall not be answerable for money received, or detriment occasioned by the other, unless it has been by some act done between them jointly. An executor or administrator has the same remedy for recovering debts and duties, as the deceased would have had if living. Neither an executor nor administrator can maintain any action for a personal injury done to the deceased, when such injury is of such a nature for which damages may be received; in actions, however, which have their origin in breach of promise, although the suit may abate by the death of the party, yet it may be revived either by his executors or administrators, who may also sue for rent in arrear, and due to the deceased in his life-time. By the custom of merchants, an executor or administrator may indorse over a bill of exchange, or promissory note. An executor or administrator may also, on the death of a lessee for years, assign over the lease, and shall not be answerable for rent after such assignment, nor shall he be liable for rent due after the lessee's death, from premises which in his life-time he had assigned to another.

An executor, or administrator, is bound only by such covenants in a lease as are said to run with the land. The executor, or administrator, previous to the distribution of the property of the deceased, must take an inventory of all his goods and chattels, which must, if required, be delivered to the ordinary upon oath. He must then collect, with all possible convenience, all the goods and effects contained in such an inventory; and whatever is so recovered that is of a saleable nature, and can be converted into money, is termed assets, and makes him responsible to such amount to the creditors, legatees, and kindred of the deceased.

The executor, or administrator, having collected in the property, is to proceed to discharge the debts of the deceased, which he must do according to the following priorities, otherwise he will be personally responsible. 1. Funeral expenses, charges of proving the will, and other expenditures incurred by the execution of his trust. 2. Debts due to the King on record, or by specialty. 3. Debts due by particular statutes, as by 30 Geo. II. c. 23; forfeitures for not burying in woollen, money due for poor-rates, and money due to the post-office. 4. Debts of record, as judgments, statutes, recognizances, and those recognized by a decree of a court of equity, and debts due on mortgage. 5. Debts on special contract, as bonds or other instruments under seal; and also rent in arrear. 6. Debts on simple contract, *viz.* such as debts arising by mere verbal promise, or by writing not under seal, as notes of hand, servants' wages, &c.

The executor is bound at his peril to take notice of debts on record, but not of other special contracts, unless he receives notice. If no suit be actually commenced against an executor or administrator, he may pay one creditor in equal degree the whole debt, though there should be insufficient remaining to pay the rest: and even after the commencement of a suit, he may, by confessing judgment to other creditors of the same degree, give them a preference. Executors and administrators are also allowed, amongst debts of equal degree, to pay themselves first; but they are not allowed to retain their own debt to the prejudice of others in a higher degree; neither shall they be permitted to retain their own debts, in preference to that of their co-executor, or co-administrator, of equal degree, but both shall be charged in equal proportion. A mortgage made by the testator

must be discharged by the representative out of the personal estate, if there be sufficient to pay the rest of the creditors and legatees: where such mortgage, however, was not incurred by the deceased, it is not payable out of the personal estate.

Executory *devise*, is defined a future interest, which cannot vest at the death of a testator, but depends upon some contingency, which must happen before it can vest; it is called so to distinguish it from a remainder, from which it differs in being less strictly restrained by technical rules.

EXEGESIS, a discourse by way of explanation or comment upon any subject.

EXEMPLIFICATION *of letters patent*, a transcript or duplicate of them, made from the inrolment thereof, and sealed with the great seal. These exemplifications are by statute equally effectual, and may be pleaded, as well as the originals. One may exemplify a patent under the great seal in Chancery; also any record, or judgment, in any of the courts at Westminster, under the seal of each court; which exemplifications may be given in evidence to a jury. It is held that nothing but matter of record ought to be exemplified.

EXERCISE, among physicians, such an agitation of the body as produces salutary effects in the animal economy. Exercise may be said to be either active or passive. The active is walking, hunting, dancing, playing at bowls, and the like; as also speaking and other labour of the body and mind; the passive is riding in a coach, on horseback, or in any other manner. Exercise may be continued to a beginning of weariness, and ought to be used before dinner, in a pure light, air; for which reason, journies and going into the country contribute greatly to preserve and re-establish health.

Exercise, in military affairs, is the ranging a body of soldiers in form of battle, and making them perform the several motions and military evolutions with different management of their arms, in order to make them expert therein.

Exercise is the first part of the military art, and from it the greatest advantage may be expected, in the expertness with which men become capable of loading and firing, and their learning and attention to act in conformity with those around them. It is not from numbers, or from inconsiderate valour that victory can rationally be hoped for. In battle, the triumph is usually derived from a knowledge of arms, and a strict attention to discipline.

Exercise *of the infantry*, includes the use of the firelock and practice of the manœuvres for regiments of foot, according to regulations used by authority. The beauty of all exercise and marching consists in seeing a soldier carry his arms well, keep his firelock steady, and the whole body without constraint. Every motion should be performed with life, and with the greatest regard to exactness; and in order to these, a regiment should never be under arms longer than two hours at a time.

Exercise *of the cavalry*, is of two sorts, *viz.* on horseback and on foot. The officers commanding squadrons must be careful to form with great celerity, and preserve just order and distances. The men must keep a steady seat upon their horses, and have their stirrups of a fit length.

Exercise *of the artillery*, is the method of teaching the regiments of artillery the use and practice of all the various machines of war, *viz.* Exercise of the light field pieces teaches the men to load, ram, and sponge the guns well; to elevate them according to the distance, by the quadrant and screw; to judge of distances and elevations without the quadrant; how to use the port-fire, match, and tubes for quick firing; how to fix the drag ropes, and use them in advancing, retreating, and wheeling, with the field-pieces; how to fix and unfix the trail of the carriage on the limbers, and how to fix and unfix the boxes for grape-shot on the carriage of each piece.

Exercise *of the garrison and battering artillery*, is to teach the men how to load, ram and sponge; how to handle the handspikes in elevating and depressing the metal to given distances, and for ricochet; how to adjust the coins, and work the gun to its proper place; and how to point and fire with exactness, &c.

Exercise *for the mortar*, is of two different sorts, *viz.* with powder and shells unloaded, and with powder and shells loaded; each of which is to teach the men their duty, and to make them handy in using the implements for loading, pointing, traversing, and firing, &c.

Exercise *of the howitzer*, differs but little from the mortar, except that it is liable to various elevations; whereas that of the mortar is fixed to an angle

of 45°; but the men should be taught the method of ricochet firing, and how to practice with grape-shot; each method requiring a particular degree of elevation.

EXERCISES are also understood of what young gentlemen or cadets learn in the military academies and riding schools; such as fencing, dancing, riding, the manual exercise, &c. The late establishment at High Wycomb is calculated to render young officers perfectly competent to all the duties of military service, provided they have been previously instructed in the first rudiments Officers are there taught and exercised in the higher branches of tactics and manœuvres.

EXERGUM, among antiquarians, a little space around or without the figures of a medal, left for the inscription, cypher, device, date, &c.

EXHALATION, a general term for all the effluvia or steams raised from the surface of the earth in form of vapour. Some distinguish exhalations from vapours, expressing by the former all steams emitted from solid bodies, and by the latter the steams raised from water and other fluids.

EXHAUSTED *receiver*, a glass or other vessel, out of which the air hath been drawn by means of the air pump. See PNEUMATICS.

EXHAUSTION, in mathematics, a method in frequent use among the ancient mathematicians, as Euclid, Archimedes, &c. that proves the equality of two magnitudes, by a deduction *ad absurdum*, in supposing that, if one be greater or less than the other, there would follow an absurdity.

This is founded upon what Euclid saith in his tenth book, *viz.* that those quantities, whose difference is less than any assignable one, are equal. For if they were unequal, be the difference never so small, yet it may be so multiplied, as to become greater than either of them: if not so, then it is really nothing. This he assumes in the proof of the first proposition of book 10, which is, that if from the greater of two quantities, you take more than its half, and from the remainder more than its half, and so continually, there will, at length, remain a quantity less than either of those proposed.

On this foundation they demonstrate, that if a regular polygon of infinite sides be inscribed in, or circumscribed about, a circle, the space, that is, the difference between the circle and the polygon, will, by degrees, be quite exhausted, and the circle be equal to the polygon.

EXHIBITION, a benefaction settled for the benefit of scholars in the universities, that are not on the foundation.

EXIGENT, in law, a writ or part of the process of outlawry on civil actions.

EXISTENCE, that whereby any thing has an actual essence, or is said to be. Mr. Locke says, "that we arrive at the knowledge of our own existence by intuition; of the existence of God by demonstration; and of other things by sensation. As for our own existence," continues that great philosopher, "we perceive it so plainly, that it neither needs, nor is capable of any proof. I think, I reason, I feel pleasure and pain; can any of these be more evident to me than my own existence? If I doubt of all other things, that very doubt makes me perceive my own existence, and will not suffer me to doubt it. If I know I doubt, I have as certain a perception of the thing doubting, as of that thought which I call doubt: experience then convinces us that we have an intuitive knowledge of our own existence."

From the knowledge of our own existence, Mr. Locke deduces his demonstration of the existence of a God.

It has been a subject of great dispute, whether external bodies have any existence but in the mind, that is, whether they really exist, or exist in idea only: the former opinion is supported by Mr. Locke, and the latter by Dr. Berkely. "The knowledge of the existence of other things, or things without the mind, we have only by sensation: for there being no necessary connection of real existence with any idea a man hath in his memory, nor of any other existence but that of God, with the existence of any particular man; no particular man can know the existence of any other being, but only when, by operating upon him, it makes itself be perceived by him. The having the idea of any thing in our mind no more proves the existence of that thing, than the picture of a man evidences his being in the world, or the visions of a dream make a true history. It is, therefore, the actual receiving of ideas from without that gives us notice of the existence of other things, and makes us know that something does exist at that time without us, which causes that idea in us, though perhaps we neither know nor consider how it does it. This notice, which we have by our senses, of the existence of things without us, though

it be not altogether so certain as intuition and demonstration, yet deserves the name of knowledge, if we persuade ourselves that our faculties act and inform us right concerning the existence of those objects that affect them: but besides the assurance we have from our senses themselves, that they do not err in the information they give us of the existence of things without us, we have other concurrent reasons; as, first, it is plain these perceptions are produced in us by external causes affecting our senses, because those that want the organs of any sense never can have the ideas belonging to that sense produced in their minds. Secondly, because we find sometimes that we cannot avoid the having those ideas produced in our minds. When my eyes are shut, I can, at pleasure, recal to my mind the ideas of light, or the sun, which former sensations had lodged in my memory; but if I turn my eyes towards the sun, I cannot avoid the ideas which the light of the sun then produces in me; which shews a manifest difference between those ideas laid up in the memory, and such as force themselves upon us, and we cannot avoid having; besides, there is nobody who doth not perceive the difference in himself between actually looking on the sun, and contemplating the idea he has of it in his memory; and therefore he hath certain knowledge that they are not both memory or fancy. Thirdly, add to this, that many ideas are produced in us with pain, which we afterwards remember without the least offence: thus, the pain of heat or cold, when the idea of it is revived in our minds, give us no disturbance, which, when felt, was very troublesome; and we remember the pain of hunger, thirst, head-ach, &c. without any pain at all, which would either never disturb us, or else constantly do it, as often as we thought of it, were there no more but ideas floating in our minds, and appearances entertaining our fancies, without the real existence of things affecting us from abroad. Fourthly, our senses, in many cases, bear witness to the truth of each other's report concerning the existence of sensible things without us: he that doubts when he sees a fire, whether it be real, may, if he pleases, feel it too, and by the exquisite pain may be convinced that it is not a bare idea, or phantom."

Dr. Berkeley, on the other hand, contends, that external bodies have no existence but in the mind perceiving them, or that they exist no longer than they are perceived: his principal arguments, which several others, as well as himself, esteem a demonstration of this system, are as follow: "That neither our thoughts, passions, or ideas formed by the imagination, exist, without the mind, is allowed; and that the various sensations impressed on the mind, whatever objects they compose, cannot exist otherwise than in a mind perceiving them, is equally evident. This appears from the meaning of the term exist, when applied to sensible things: thus, the table I write on exists, *i. e.* I see and feel it, and were I out of my study I should say it existed, *i. e.* that were I in my study I should see and feel it as before. There was an odour, *i. e.* I smelt it, &c.; but the existence of unthinking beings, without any relation to their being perceived, is unintelligible: their *esse* is *percipi*." Then, to shew that the notion of bodies is grounded on the doctrine of abstract ideas, "What," he asks, "are light and colours, heat and cold, extension and figure, in a word, the things we see and feel, but so many sensations, notions, ideas, or impressions on the sense; and is it possible to separate, even in thought, any of these from perception? The several bodies, then, that compose the frame of the world, have not any subsistence without a mind: their *esse* is to be perceived or known; and if they are not perceived by me, nor by any other thinking being, they have no shadow of existence at all: the things we perceive are colour, figure, motion, &c. that is, the ideas of those things; but has an idea any existence out of the mind? To have an idea is the same thing as to perceive; that, therefore, wherein colour, figure, &c. exist, must perceive them. It is evident, therefore, that there can be no unthinking substance, or substratum of those ideas. But you may argue, if the ideas themselves do not exist without the mind, there may be things like them, whereof they are copies or resemblances, which exist without the mind. It is answered, an idea can be like nothing but an idea, a colour or figure can be nothing else but another colour or figure. It may be farther asked, whether those supposed original or external things, whereof our ideas are the pictures, be themselves perceivable or not? If they be not, I appeal to any one, whether it be sense to say a colour is like somewhat which is invisible, hard or soft, like somewhat untangible, &c. Some distinguish between primary and secondary qualities; the former, *viz.* extension, solidity, figure, motion, rest, and number, have a real existence out of the mind; for the

latter, under which come all other sensible qualities, as colours, sounds, tastes, &c they allow the ideas we have of them are not resemblances of any thing without the mind, or unperceived, but depend on the size, texture, motion, &c. of the minute particles of matter. Now it is certain that those primary qualities are inseparably united with the other secondary ones, and cannot even in thought be abstracted from them, and therefore must only exist in the mind. Again, great or small, swift or slow, are allowed to exist no where without the mind, being merely relative, and changing as the frame or position of the organ changes: the extension, therefore, that exists without the mind is neither great nor small, the motion neither swift nor slow, *i. e.* they are nothing. That number is a creature of the mind is plain, (even though the other qualities were allowed to exist) from this, that the same thing bears a different denomination of number, as the mind views it with different respects: thus, the same extension is 1, 3, or 36, as the mind considers it, with reference to a yard, a foot, or an inch.

"In effect, after the same manner as the modern philosophers prove colours, taste, &c. to have no existence in matter, or without the mind, the same thing may be proved of all sensible qualities whatever: thus they say, heat and cold are only the affections of the mind, not at all patterns of real beings existing in corporeal substances, for that the same body which seems cold to one hand seems warm to another. Now, why may we not as well argue, that figure and extension are not patterns or resemblances of qualities existing in matter, because, to the same eye, at different stations, or to eyes of different structure, at the same station, they appear various? Again, sweetness, it is proved, does not exist in the thing sapid, because the thing remaining unaltered, the sweetness is changed to bitterness, as in a fever, or by any otherwise vitiated palate. Is it not as reasonable to say, that motion does not exist out of the mind, since, if the succession of ideas in the mind become sinister, the motion, it is acknowledged, will appear slower, without any external alteration? Again, were it possible for solid figured bodies to exist out of the mind, yet it were impossible for us ever to know it: our senses, indeed, give us sensations of ideas, but do not tell us that any thing exists without the mind, or unperceived, like those which are perceived; this the materialists allow. No other way therefore remains, but that we know them by reasons inferring their existence from what is immediately perceived by sense; but how should reason do this, when it is confessed there is not any necessary connection between our sensations and these bodies? It is evident, from the phænomena of dreams, phrensies, &c. that we may be affected with the ideas we now have, though there were no bodies existing without them; nor does the supposition of external bodies at all forward us in conceiving how our ideas should come to be produced."

EXOACANTHA, in botany, a genus of the Pentandria Digynia class and order. Natural order of Umbellatæ. Essential character: involute spiny; involucle halved, with unequal rays; flowers all hermaphrodite, with equal, inflex, heart-shaped petals; seeds ovate, striate. There is but one species, *viz.* E. heterophylla, found by Billardiere near Nazareth.

EXOCŒTUS, the *flying fish*, in natural history, a genus of fishes of the order Abdominales. Generic character: head scaly; mouth without teeth; jaws connected on each side; gill membrane ten-rayed; pectoral fins very long and large, and giving, to a certain degree, the power of flight. There are five species. We shall particularly notice the E. exilien, or the Mediterranean flying fish. This is about fourteen inches in length, and is found principally in the Mediterranean and Atlantic Seas, frequently alone, and sometimes in small companies. By the extraordinary length of its pectoral fins it is enabled to quit the water and support a flight, about three feet above the surface, for the distance of eighty or a hundred yards, after which it is obliged to return to the water and moisten its fins, which, even in this short progress, become hard and dry. These fishes are persecuted by the dorado under the water, and by the gull, or albatross, above the surface of it, and thus often escape destruction by the one, only to incur it from the other. This faculty of maintaining short flights in the air is possessed by several other fishes, particularly by the scorpæna and the trigla. The air-bladder of the flying fish is extremely large, and, of consequence, highly assisting to its aerial progress. The roe of this fish is reported to be highly caustic; the smallest quantity applied to the tongue producing some degree of excoriation. For a representa-

tion of the oceanic flying fish, see Pisces, Plate IV. fig. 2.

EXORDIUM, in rhetoric, is the preamble or beginning, serving to prepare the audience for the rest of the discourse. Exordiums are of two kinds, either just and formal, or vehement and abrupt. The last are most suitable on occasions of extraordinary joy, indignation, or the like. All exordiums should be composed with a view to captivate the good will, or attract the attention of the audience. The first may be done by paying them some compliment: thus St. Paul, "I think myself happy, king Agrippa, because I shall answer for myself this day before thee, touching all the things whereof I am accused with the Jews, especially because I know thee to be expert in all customs and questions which are among the Jews."

The requisites in an exordium are, 1. Propriety, whereby it becomes of a piece with the subject, and matches it as a part does a whole: in this the Greeks were very defective. 2. Modesty, which very much recommends the orator to the favour of his audience. And, 3. Brevity, not amplified or swelled with a detail of circumstances.

EXOTERIC, and ESOTERIC, terms denoting external and internal, and applied, to the double doctrine of the ancient philosophers: the one was public, or exoteric, the other secret or esoteric. The first was that which they taught openly to the world, the latter was confined to a small number of disciples. See PERIPATETICS.

EXOTIC, an appellation denoting a thing to be the produce of foreign countries. Exotic plants of the hot climates are very numerous, and require the utmost attention of the gardener to make them thrive with us.

EXPANSION, in natural philosophy, the enlargement or increase of bulk in bodies, chiefly by means of heat. This is one of the most general effects of caloric, being common to all bodies whatever, whether solid or fluid, or in an aeriform state. In some cases bodies seem to expand as they grow cold, as water in the act of freezing; this, however, is known to be no exception to the general rule, but is owing to the arrangement of the particles, or to crystallization, and is not a regular and gradual expansion, like that of metals, or other solid substances, by means of heat. In various metals, likewise, an expansion takes place in passing from a fluid to a solid state, which is accounted for in the same way. The expansion of solids is exhibited by the PYROMETER (which see.) A rod of iron, for instance, becomes sensibly longer and larger in all its dimensions in passing from a low to a high state of temperature. The expansion of fluids is shewn by the thermometer, and is the principle upon which that useful instrument is constructed; by immersing a thermometer into hot water, the mercury, or other fluid, contained in it, immediately expands. See THERMOMETER. The degree of expansion produced in different liquids varies very considerably. In general, the denser the fluid, the less the expansion; water expands more than mercury, and alcohol, which is lighter than water, expands more than water. The expansion of aeriform fluids may be exhibited by bringing a bladder, partly filled with air, and the neck closely tied, near the fire; the bladder will soon be distended, and will, if the heat be strong enough, burst. Metals expand in the following order; those that expand most are placed first: zinc, lead, tin, copper, bismuth, iron, platina.

EXPECTATION *of life*, a term used by the writers on life annuities and reversions, and which, according to Dr. Price, signifies the mean continuance of any given single, joint, or surviving lives, according to any given table of observations: that is, the number of years, which, taking them one with another, they actually enjoy, and may be considered as sure of enjoying; those who live or survive beyond that period enjoying as much more time, in proportion to their number, as those who fall short of it enjoy less. See LIFE, *duration of*.

EXPECTORANTS, an appellation given to those medicines which facilitate the discharging the contents of the lungs.

EXPECTORATION, the act of evacuating or bringing up phlegm, or other matters out of the trachea, lungs, &c. by coughing, hauking, spitting, &c.

EXPEDITION, in military affairs, is cheifly used to denote a voyage or march against an enemy, the success of which depends on rapid and unexpected movements. No rules have been, or probably can be, given for the application of expeditions generally; they depend on circumstances that cannot be foreseen; they seem to depend on the following maxims: 1. Secrecy of preparation and concealment of design. 2. The means must

be proportional to the end. 3. There must be an accurate knowledge of the state and situation of the country. 4. The plan must be well arranged, and the commander perfectly adapted to the particular sort of business.

EXPERIENCE, a kind of knowledge acquired by long use, without any teacher. Mr. Locke says that men receive all the materials of knowledge from experience and observation. Experience then consists in the ideas of things we have seen or read, which the judgment has reflected on, to form itself a rule or method.

EXPERIMENTAL *philosophy*, that philosophy which proceeds on experiments, which deduces the laws of nature, and the properties and powers of bodies, and their actions upon each other, from sensible experiments and observations. The business of experimental philosophy is to inquire into and to investigate the reasons and causes of the various appearances or phænomena of nature, and to make the truth or probability thereof obvious and evident to the senses, by plain, undeniable, and adequate experiments, representing the several parts of the grand machinery and agency of nature.

In our inquries into nature, we are to be conducted by those rules and maxims which are found to be genuine, and consonant to a just method of physical reasoning; and these rules of philosophising are, by the greatest master in science, Sir Isaac Newton, reckoned four, which are as follows:

1. More causes of natural things are not to be admitted, than are both true, and sufficient to explain the phænomena; for nature does nothing in vain, but is simple, and delights not in superfluous causes of things.

2. And, therefore, of natural effects of the same kind, the same causes are to be assigned, as far as it can be done; as of respiration in man and beasts, of the descent of stones in Europe and America, of light in a culinary fire and in the sun, and of the reflection of light in the earth and in the planets.

3. The qualities of natural bodies which cannot be increased or diminished, and agree to all bodies in which experiments can be made, are to be reckoned as the qualities of all bodies whatsoever: thus, because extension, divisibility, hardness, impenetrability, mobility, the vis inertiæ, and gravity, are found in all bodies which fall under our cognizance or inspection, we may justly conclude they belong to all bodies whatsoever, and are therefore to be esteemed the original and universal properties of all natural bodies.

4. In experimental philosophy, propositions collected from the phænomena by induction are to be deemed (notwithstanding contrary hypotheses) either exactly or very nearly true, till other phænomena occur, by which they may be rendered either more accurate, or liable to exception. This ought to be done, lest arguments of induction should be destroyed by hypothesis.

These four rules of philosophising are premised by Sir Isaac Newton to his third book of the "Principia;" and more particularly explained by him in his "Optics," where he exhibits the method of proceeding in philosophy, the first part of which is as follows:

"As in mathematics, so in natural history, the investigation of difficult things, by way of analysis, ought always to precede the method of composition. This analysis consists in making experiments and observations, and in drawing general conclusions from them by induction, (*i. e.* reasoning from the analogy of things by natural consequence) and admitting no objections against the conclusions but what are taken from experiments or certain truths. And although the arguing from experiments and observation, by induction, be no demonstration of general conclusions, yet it is the best way of arguing which the nature of things admits of, and may be looked on as so much the stronger, by how much the induction is more general; and if no exception occur from phænomena, the conclusion may be pronounced generally: but if, at any time afterwards, any exception shall occur from experiments, it may then be pronounced with such exceptions: by this way of analysis we may proceed from compounds to ingredients, and from motions to the causes producing them; and, in general from effects to their causes; and from particular causes to more general ones, till the argument ends in the most general: this is the method of analysis. And that of synthesis, or composition, consists in assuming causes, discovered and established as principles, and by them explaining the phænomena proceeding from them, and proving the explanations." See Acoustics, Aerostation, Electricity, Hydrostatics, Magnetism, Mechanics, Optics, Pneumatics, &c. &c.

EXPERIMENTUM *crucis*, a capital, leading, or decisive experiment; thus termed, either on account of its being like a cross or direction post, placed in the meeting of several roads, guiding men to the true knowledge of the nature of that thing they are inquiring after; or, on account of its being a kind of torture, whereby the nature of the thing is, as it were, extorted by force.

EXPIRATION, in physic, that part of respiration, whereby the air is expelled or driven out of the lungs. See PHYSIOLOGY.

EXPLOSION, in natural philosophy, a sudden and violent expansion of an aerial or other elastic fluid, by which it instantly throws off any obstacle that happens to be in the way, sometimes with incredible force, and in such a manner as to produce the most astonishing effects. It differs from expansion in this, that the latter is a gradual and continued power, acting uniformly for some time; whereas the former is always sudden, and only of momentary duration. The expansions of solid bodies do not terminate in violent explosions, on account of their slowness, and the small space through which the metal, or other expanding substance, moves. Thus wedges of dry wood driven into stone, and wetted, will cleave the most solid blocks, but they never throw the parts to any distance, as is the case with gunpowder; but the expansion of elastic fluids will burst solid substances, and throw the fragments a great way off: for this two reasons have been assigned: 1. The immense velocity with which aerial fluids expand, when suddenly affected with high degrees of heat: and 2. The great celerity with which they acquire heat, and are affected by it. As an example, air, when heated as much as iron, when brought to a white heat, is expanded to four times its bulk; but the metal itself will not be expanded the 500th part of the space. In the case of gunpowder, which is well known as an explosive substance, the velocity with which the flame moves is estimated at 7000 feet in a second. Hence the impulse of the fluid is inconceivably great, and the obstacles on which it strikes are hurried off with vast velocity, *viz.* at the rate of 27 miles per minute. The velocity of the bullet is also promoted by the sudden propagation of the heat through the whole body of air, as soon as it is extricated from the materials of which the gunpowder is made, so that it strikes at once. Hence it has been inferred, that explosion depends first on the quantity of elastic fluid to be expanded: secondly, on the velocity it acquires by a certain degree of heat: and, thirdly, on the celerity with which the degree of heat affects the whole expansive fluid.

EXPONENT, in algebra, is a number placed over any power, or involved quantity, to shew to what height the root is raised: thus, 2 is the exponent of x^2, and 4 the exponent of x^4, or $xxxx$. The rule for dividing powers of the same quantity is, to substract the exponents, and make the difference the exponent of the quotient: if, therefore, a lesser power is divided by a greater, the exponent of the quotient must, by this rule, be negative: thus, $\frac{a^4}{a^6} = a^{4-6} = a^{-2}$. But $\frac{a^4}{a^6} = \frac{1}{a^2}$; and hence $\frac{1}{a^2}$ is expressed by a^2, with a negative exponent. It is also obvious, that $\frac{a}{a} = a^{1-1} = a^0$; but $\frac{a}{a} = 1$, and therefore $a^0 = 1$. After the same manner, $\frac{1}{a} = \frac{a^0}{a} = a^{0-1} = a^{-1}$; $\frac{1}{aa} = \frac{1}{a^2} = a^{0-2} = a^{-2}$; $\frac{1}{aaa} = a^{0-3} = a^{-3}$; so that the quantities, a, 1, $\frac{1}{a}$, $\frac{1}{a^2}$, $\frac{1}{a^3}$, $\frac{1}{a^4}$, &c. may be expressed thus, a^1, a^0, a^{-1}, a^{-2}, a^{-3}, a^{-4}, &c. These are called the negative powers of a, which have negative exponents; but they are at the same time positive powers of $\frac{1}{a}$, or $^{-}a_1$

EXPONENT *of a ratio*, is the quotient arising from the division of the antecedent by the consequent: thus, in the ratio of 5 to 4, the exponent is $1\frac{1}{4}$; but the exponent of 4 : 5, is $\frac{4}{5}$. If the consequent be unity, the antecedent itself is the exponent of the ratio: thus the exponent of the ratio 4 : 1 is 4. Wherefore the exponent of a ratio is to unity as the antecedent is to the consequent. Although the quotient of the division of the antecedent by the consequent is usually taken for the exponent of a ratio, yet in reality the exponent of a ratio ought to be a logarithm. And this seems to be more agreeable to Euclid's definition of duplicate and triplicate ratios, in his fifth book. For 1, 3, 9, are continual proportionals; now if $\frac{1}{3}$ be the exponent of the ratio of 1 to 3, and $\frac{3}{9}$ or $\frac{1}{3}$ the exponent of the ratio of 3 to 9; and $\frac{1}{9}$ the exponent of the ra-

tio of 1 to 9; and since, according to Euclid, if three quantities be proportional, the ratio of the first to the third is said to be the duplicate of the ratio of the first to the second, and of the second to the third; therefore, according to this, $\frac{1}{9}$ must be the double of $\frac{1}{3}$, which is very false. But it is well known, the logarithm of the ratio of 1 to 9, that is, the logarithm of 9, is the double of the ratio of 1 to 3, or 3 to 9, that is, the logarithm of 3. From whence it appears that logarithms are more properly the exponents of ratios, than numerical quotients; and Dr. Halley, Mr. Cotes, and others, are of the same opinion.

Exponent, is also used in arithmetic, in the same sense as index or logarithm.

EXPONENTIAL *curve*, is that whose nature is expressed by an exponential equation. The area of any exponential curve, whose nature is expressed by this exponential equation $x^x = y$ (making $1 + v = x$ will be $\frac{1}{0.1.2} v^2 + \frac{1}{0.1.2.3} v^3 - \frac{1}{0.1.2.3.4} v^4 + \frac{1}{0.1.2.3.4.5} v^5 \quad \frac{1}{0.1.2.3.4.5.6}$, v^6, &c.

Exponential *equation*, is that wherein there is an exponential quantity. See the next article.

Exponential *quantity*, is a quantity whose power is a variable quantity, as x^x, a^x. Exponential quantities are of several degrees and orders, according as the exponents themselves are more or less involved. If the exponent be a simple quantity, as zy, it is called an exponential of the first or lowest degree; but when the exponent itself is an exponential of the first degree, as zy^x, it is called an exponential of the second degree. In like manner, if the exponent itself be an exponential of the second degree, as $xy^{x^{\circ}}$, it is called an exponential of the third degree, &c.

EXPORTATION, the act of sending goods out of one country into another. In modern times it has been the principal object of commercial policy, in almost every country, to encourage exportation, except with respect to a few particular articles; the export of manufactured goods has been promoted, with a view of encouraging the internal industry of the country, and the export of foreign produce, as a means of drawing wealth from other countries by the profits of the carrying trade. The excess of the value of goods exported, beyond that of the imports has usually been considered as a criterion of the profits which a country derives from foreign trade; but this is a very fallacious mode of determining a point of great importance; advantageous foreign trade might long exist, even if the imports constantly exceeded the value of the exports. The laws in force relating to exportation, consist principally of prohibitory or restrictive regulations, respecting bullion, corn, wool, machinery, and tools used in various branches of manufactures, the exportation of which, it is thought, might diminish the necessary supply of provisions for the consumption of the country, or enable foreigners to rival valuable branches of its manufactures. The acts relative to the exportation of wool prohibit the exportation, not only of the article itself, but also of live sheep, rams, or lambs, from Great Britain, Ireland, Jersey, Guernsey, Alderney, Sark, or Man, on penalty of the forfeiture thereof, and of the ships conveying the same; also 3*l.* for every sheep, &c. and the offender to suffer three months solitary imprisonment; for a second offence 5*l.* per sheep, &c. and six months imprisonment; except wether sheep for ships' use only, put on board by licence of the port officer of the customs. A limited quantity of wool is, however, permitted to be exported from the port of Southampton to Jersey, Guernsey, Alderney, and Sark. The duties on exportation, payable in Great Britain and Ireland, which were formerly the principal branch of the revenue derived from foreign trade, are now of small amount, in comparison with the duties payable on goods brought into the country. See Customs.

EXPRESSED *oil*. See Oil.

EXPRESSION, in chemistry, or pharmacy, denotes the act of expressing out the juices or oils of vegetables, which is one of the three ways of obtaining them; the other two being by infusion and decoction. The hard fruits require to be well bruised previously to expression, but herbs are only to be moderately bruised. They are then to be included in a hair bag, and pressed between wooden plates in the common screw press, till the juice ceases to run. The expression of oils is performed nearly in the same manner as that of juices, only iron plates are to be used instead of wooden ones. The insipid oils of all unctuous seeds are obtained uninjured by this operation, if performed without the aid of heat, which

though it promotes the extraction of the oil, gives it an ungrateful flavour The oils expressed from aromatic substances generally carry with them a portion of their essential oil. Hence the smell and flavour of the expressed oils of nutmegs and mace.

Expression, in rhetoric, the elocution, diction, or choice of words in a discourse. Beautiful expression is the natural and true light of our thoughts: it is to this we owe all the excellencies in discourse, which gives a kind of vocal life and spirit. As the principal end of discourse is to be understood, the first thing we should endeavour to obtain is a richness of expression, or habit of speaking so well, as to make our thoughts easily understood.

Expression, in painting, a natural and lively representation of the subject, or of the several objects intended to be shewn. The expression consists chiefly in representing the human body, and all its parts, in the action suitable to it: in exhibiting in the face the several passions proper to the figures, and observing the motions they impress on the external parts. See Painting.

EXSICCATION, in pharmacy, the drying of moist bodies, for which two methods are usually employed; in one the humid parts are exhaled by heat, in the other they are imbibed or absorbed by substances, whose texture is adapted to the purpose. Bodies combined with, or dissolved in a fluid, require the first: such as are only superficially mixed with it, are separated by the second method. Vegetables are usually exsiccated by the natural warmth of the air, but the assistance of a gentle artificial heat is often found very useful. By a moderate fire the more tender flowers may be dried in a short time, without any considerable loss either of their odour or lively colour, which would be injured, or perhaps destroyed, by the more slow exsiccation in the air. Some plants, particularly those of the acrid kind, lose their virtues by that process.

EXTENSION, in philosophy, one of the common and essential properties of body, or that by which it possesses or takes up some part of universal space, which is called the place of that body.

Extension is divided, 1. Either into length only, and then it is called a line; or, 2. Into length and breadth, which is called a superficies; or, 3. Into length, breadth, and depth, which is called a solid; being the three dimensions according to the quantity of which the magnitude or bulk of bodies are estimated. Extension, according to Mr. Locke, is space considered between the extremities of matter, which fills up its capacity with something solid, tangible, and moveable. Space, says that philosopher, may be conceived without the idea of extension, which belongs to body only.

EXTENSOR, an appellation given to several muscles, from their extending or stretching the parts to which they belong. See Anatomy.

EXTENT, in law, a writ of execution or commission to the sheriff, of one who, being bound by statute, has forfeited his bond, for the valuing of lands or tenements; sometimes the act of the sheriff upon this writ.

EXTERMINATION, in general, the extirpating or destroying something. In algebra, surds, fractions, and unknown quantities, are exterminated by rules for reducing equations. Thus to take away the fractional form from these equations $\frac{a}{b}=\frac{x}{y}$; and $\frac{a^2+b^2}{2c}=\frac{x}{y}$; in both cases we multiply the numerator of one fraction by the denominator of the other, and the equations become $ay=bx$ and $a^2y+b^2y=2cx$: so again, to take away the sign of the square, or cube, or other root, as $\sqrt[2]{a^2+y^2}=4z$, we raise the $4z$ to the second power, and take off the sign of the root on the other side of the equation thus, $a^2+y^2=16z^2$: and when $n\sqrt{a+b}=x$: then $a+b=xn$. To exterminate a quantity from any equation there are divers rules. See Algebra.

We shall however give an instance in this place: thus to exterminate y out of these two equations $a+x=b+y$
$3b=2x+y$
subtract the upper equation from the under and there remains $3b-a-x=2x-b$, hence $3x=4b-a$ and $4=1\frac{b-a}{3}$.

Suppose also two equations given, involving two unknown quantities, as $\left\{\begin{matrix} ax+by=c \\ dx+ey=f \end{matrix}\right\}$ then shall $y=\frac{af-dc}{ae-db}$

Where the numerator is the difference of the products of the opposite coefficients, in the orders in which y is not found; and the denominator is the difference of the products of the opposite coefficients, taken from the orders that involve the unknown quantities. For from the first

equation it appears that $a x = c - b y$, and $x = \frac{c - b y}{a}$; and from the second equation, that $d x = f - c y$, and $x = \frac{f - e y}{d}$. Therefore $\frac{c - b y}{a} = \frac{f - e y}{d}$; and $c d - d b y = a f - a e y$, whence $a e y - d b y = a f - c d$; and $y = \frac{a f - c d}{a e - d b}$.

To exemplify this theorem, suppose $a = 5$, $b = 7$, $c = 100$, $d = 3$, $e = 8$, and $f = 80$. Then $y = \frac{\overline{5 \times 80} - \overline{3 \times 100}}{\overline{5 \times 8} - \overline{3 \times 7}} = \frac{100}{19} = 5\frac{5}{19}$; and $x = \frac{240}{19} = 12\frac{12}{19}$.

If three or four equations are given, involving three or four unknown quantities, their values may be found much in the same manner.

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A factor, in law and in merchandise, is one authorized to sell goods and merchandise, and otherwise act for his principal, with an allowance or commission for his care. He must pursue his orders strictly. He is accountable for all lawful goods coming to his hands; yet if the factor buy goods for his principal, and they receive damage in his possession, through no negligence of his, the principal shall bear the loss; and if a factor is robbed, he shall be discharged; if a factor act contrary to his orders in selling goods, he is liable for the loss, though there may be a probability of advantage by his act: so he is liable for not making insurance, if ordered to do so.

FACTOR, in multiplication, a name given to the multiplier and multiplicand, because they constitute the product. See ARITHMETIC.

FACTORAGE, called also commission, is the allowance given to factors by the merchant who employs them.

FACTORY, is a place where a considerable number of factors reside, to negociate for their masters and employers. The most considerable factories belonging to the British are those established in the East Indies. There were also factories in Portugal, Turkey, and at Hamburgh, Petersburgh, Dantzic, and Amsterdam, all endowed with certain privileges. The ascendency of the French Emperor, for the present, at least, has put an end to these, or to the most of them. We trust, however, that a change of circumstances may hereafter place things on their old footing.

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FACTITIOUS, any thing made by art, in opposition to what is the produce of nature. Thus factitious cinnabar is opposite to native cinnabar. See Cinnabar.

FACTOR, in commerce, is an agent or correspondent residing beyond the seas, or in some remote part, commissioned by merchants to buy or sell goods on their account, or assist them in carrying on their trade.

A factor, in law and in merchandise, is one authorized to sell goods and merchandise, and otherwise act for his principal, with an allowance or commission for his care. He must pursue his orders strictly. He is accountable for all lawful goods coming to his hands; yet if the factor buy goods for his principal, and they receive damage in his possession, through no negligence of his, the principal shall bear the loss; and if a factor is robbed, he shall be discharged; if a factor act contrary to his orders in selling goods, he is liable for the loss, though there may be a probability of advantage by his act: so he is liable for not making insurance, if ordered to do so.

Factor, in multiplication, a name given to the multiplier and multiplicand, because they constitute the product. See Arithmetic.

FACTORAGE, called also commission, is the allowance given to factors by the merchant who employs them.

FACTORY, is a place where a considerable number of factors reside, to negociate for their masters and employers. The most considerable factories belonging to the British are those established in the East Indies. There were also factories in Portugal, Turkey, and at Hamburgh, Petersburgh, Dantzic, and Amsterdam, all endowed with certain privileges. The ascendency of the French Emperor, for the present, at least, has put an end to these, or to the most of them. We trust, however, that a change of circumstances may hereafter place things on their old footing.

FACULÆ, in astronomy, certain bright and shining parts, which the modern astronomers have, by means of telescopes, observed upon or about the surface of

the sun; they are but very seldom seen. One was seen by Hevelius in 1634, whose breadth was said to be equal to a third part of the sun's diameter

FACULTY, in law, a privilege granted to a person, by favour and indulgence, of doing what, by law, he ought not to do. For granting these privileges there is a court under the Archbishop of Canterbury, called the court of the faculties, the chief officer whereof is styled master of the faculties, who has a power of granting dispensations in divers cases, as to marry without the bans being first published; to eat flesh on days prohibited; to ordain a deacon under age; for a son to succeed his father in his benefice; a clerk to hold two or more livings, &c.

Faculty, in the schools, a term applied to the different members of an university, divided according to the arts and sciences taught there: thus in most universities there are four faculties, *viz.* 1. Of arts, which include humanity and philosophy. 2. Of theology. 3. Of physic. And, 4. Of civil law. The degrees in the several faculties of our universities are those of bachelor, master, and doctor.

Faculty *of advocates*, a term applied to the college or society of advocates in Scotland, who plead in all actions before the Court of Session. They meet in the beginning of every year, and choose the annual officers of the society, *viz.* dean, treasurer, clerks, private and public examinators, and a curator of the library.

FÆCULA, in chemistry, the substance obtained by bruising or grinding certain vegetables, or grain, in water; the fæcula is that part which, after standing some time, falls to the bottom; this, in plants, appears to be only a slight alteration of their mucilage, for it differs from mucilage in no other respect than in being insoluble in cold water. Most plants contain fæcula, but the seeds of gramineous and leguminous vegetables, and all tuberose roots, contain it in great abundance.

FAGARA, in botany, a genus of the Tetrandria Monogynia class and order. Natural order of Dumosæ. Terebintaceæ, Jussieu. Essential character: calyx four-cleft; corolla four-petalled; capsule two-valved, with one seed. There are ten species.

FAGONIA, in botany, a genus of the Decandria Monogynia class and order. Natural order of Gruinales. Rutaceæ, Jussieu. Essential character: calyx five-leaved; petals five, cordate; capsule five-celled, ten-valved, with one seed in each cell. There are three species.

FAGRÆA, in botany, so called in honour of Jonas Theodore Fagræus, M. D. a genus of the Pentandria Monogynia class and order. Natural order of Contortæ. Apocineæ, Jussieu. Essential character: calyx bell-shaped; corolla funnel-shaped; berry two-celled, fleshy; seeds globular; stigma peltate. Only one species.

FAGUS, in botany, *chesnut tree*, a genus of the Monoecia Polyandria class and order. Natural order of Amentaceæ. Essential character: male, calyx five-cleft, bell-shaped; corolla none; stamina twelve: female, calyx four toothed; corolla none; styles three; capsule muricate, four-valved; seeds two. There are five species, *viz.* two chesnut trees, and three of the beech, one of which is a native of Cochin-china.

FAINT *action*, or Feigned *action*, in law, is a sort of fictitious suit, contrived for the purpose of trying a particular question of fact, and is generally directed by the Court of Chancery.

FAIR, a greater kind of market, granted to a town, by privilege, for the more speedy and commodious providing of such things as the place stands in need of. It is incident to a fair, that persons shall be free from being arrested in it for any other debt contracted than what was contracted in the same; or, at least, promised to be paid there. These fairs are generally kept once or twice a year, and, by statute, they shall not be held longer than they ought, by the lords thereof, on pain of their being seized into the King's hands, &c. Also proclamation is to be made how long they are to continue; and no person shall sell any goods after the time of the fair is ended, on forfeiture of double the value, one fourth to the prosecutor, and the rest to the King. There is a toll usually paid in fairs, on the sale of things, and for stallage, picage, &c.

Fairs and Markets, in law. No person can claim a fair or market, unless by grant from the King, or by prescription, which supposes such grant. Owners and governors of fairs are to take care that every thing be sold according to just weight and measure, and for that and other purposes may appoint a clerk of the fair or market, who is to mark

and allow such weights, and for his duty can only take his reasonable and just fees.

Generally, all regular sales of things usually sold there shall be good, not only between the parties, but also binding on all those that have any right or property therein.

FAIRY *rings*. The circles of dark-green grass, frequently observed in old pastures, have long been known under the name of fairy rings, and have generally been supposed to be occasioned, in some way or other, by electricity. Dr. Wollaston has, in a late volume of the "Transactions of the Royal Society," given a new and very ingenious theory, of which we shall present our readers with a brief account, premising that Mr. Davy, in the course of his lectures at the Royal Institution, had occasion to refer to the subject, and seemed to coincide in opinion with Dr. Wollaston. That which first attracted his notice was the position of certain fungi, which are always found growing upon these circles, if examined in a proper season. The position of these fungi led him to imagine, that the progressive increase from a central point was the probable mode of formation of the ring: hence he conjectured that the soil, which had once contributed to the support of the fungi, might be so exhausted of some peculiar pabulum necessary for their production, as to be rendered incapable of producing a second crop. The second year's crop would, if this theory be just, appear in a small ring surrounding the original centre of vegetation, and at every succeeding year the defect of nutriment on one side would necessarily cause the new roots to extend themselves solely in the opposite direction, and would occasion the circle of fungi continually to proceed, by an annual enlargement, from the centre outwards. An appearance of luxuriance of the grass would follow as a natural consequence, as the soil of an interior circle would always be enriched by the decayed roots of fungi of the year's growth. This theory is supported by some observations of Dr. Withering; and Dr. Wollaston says, by way of confirmation, that whenever two adjacent circles are found to interfere, they not only do not cross each other, but both circles are invariably obliterated between the points of contact; the exhaustion occasioned by each obstructs the progress of the other, and both are starved. Phil. Trans. 1807, Part. II.

Though it cannot be doubted that most fairy rings, if not all of them, have considerable relation to the running of a fungus, there, nevertheless, seems reason to conclude that electricity may likewise be concerned in their production. The electrical effect may relate to fairy rings of a different kind from those occasioned by the fungus, or it may have been antecedent to the production of the vegetable. It is a familiar effect in our experiments, that the spark proceeding from a positive conductor breaks or radiates at about one-third of its course, and strikes the receiving conductor by a central spark surrounded by other smaller ones. The concentric rings produced upon polished metallic surfaces by the strong explosion of a battery, as first observed by Priestley, appears to be a fact of the same kind; and the forked radiations of lightning are well known. The editor of this work related in the Phil. Journal, Vol. I. 4to. some events which happened in Kensington Gardens in June, 1781, when a very powerful thunder storm passed over the western extremity of London. The explosions were very marked and distinct, and in many instances forked at the lower end, but never at the top; from which it seems proper to conclude, that the general mass of clouds, or, at least, that extremity which passed over London, was in the state called positive.

Five days afterwards, upon visiting Kensington Gardens, it was observed, that every part of that extensive piece of ground shewed marks of the agency of the lightning, chiefly by discolouration of the grass in zigzag streaks, some of which were fifty or sixty yards in length. Instances of this superficial course of the lightning along the ground, before it enters the earth, are sufficiently frequent. But the circumstances applicable to our present subject is, that five trees, out of a grove consisting of seven, had been struck by the lightning. Two of them, which stood on the outside to the westward, had holes torn in the ground close to the trunk; and round one of these trees was a space of six feet in diameter, in which the grass was very much scorched. Another tree on the west was surrounded by a faint ring of burnt or faded grass, which seemed to be occasioned by some earlier stroke, as the vegetation had began to shoot up again. Another tree, standing on the outside to the south, was surronnded by a ring of twelve feet

diameter and eighteen inches broad. Within the ring the grass was fresh; but on the surface of the ring, the grass and the ground were much burned. To the eastward of the tree, upon the ring itself, were two holes, in which the ground had the appearance of ashes. Another tree, on the east side of the grove, had the half of a faint ring to the westward. And, lastly, a tree which stood in the middle was surrounded by a faint ring of twelve feet diameter, within which the grass was unhurt; and to the westward, at the distance of about three feet from the inner ring, was part of another similar ring, of nearly the same appearance; the verdure being unhurt in the interval between the rings.

FALCO, the *falcon*, in natural history, a genus of birds of the order Accipitres. Generic character: the bill hooked and covered at the base with a cere; head and neck covered with closely-set feathers; tongue bifid at the end; nostrils placed in the cere; legs and feet scaly; middle toe connected with the outermost by a strong membrane as far as the first joint; claws large, much hooked, and very sharp; the female stronger and larger than the male. The falcon tribe uniformly have close set feathers on the head and neck, and in this respect are particularly distinguished from the vulture tribe, which are destitute of feathers always on part of the head, and sometimes on the whole head and neck. The claws of the falcon class are more hooked and sharp also than those of the vulture. The falcon derives exquisite delight from destroying its prey, and devouring it while fresh. Though it will sometimes devour a quantity of food calculated to excite astonishment, at one repast, it will endure abstinence of several day's duration, and has been even stated by some to survive in situations, in which, for weeks, it has not had the smallest supply. It lives on fish, as well as on flesh, and also on snakes and reptiles. It is confined to no particular climate, but found in almost all. To the falcon class belongs the eagle, which takes the precedence among birds, as the lion among quadrupeds, from its strength, activity, and courage; and some ingenious naturalists have been fond of running a parallel between these animals to a considerable extent and minuteness. It is observed of the eagle, that he never undertakes a chase singly, but when the female is engaged in incubation, or in feeding her young; during this period he supplies, by his solitary exertions, the wants of his partner and of himself; at every other season their efforts are united in the pursuit of prey. They often soar beyond the reach of the human eye; but, though unseen, their sounds are heard with considerable distinctness, and have been compared to the barking of a dog.

There belong to the falcon genus, according to Latham, 98 species, and Gmelin enumerates no fewer than 136. The following merit the principal attention.

F. chryasætus, or the golden eagle, measures more than three feet in length, and above eight in breadth, and weighs about 16 pounds; the male weighs little more than two-thirds of the female. This bird has been known to breed in the highest mountains of Wales, and among the Cheviot hills, but is very rarely indeed recognized in Great Britain, though it is said to be seen not unfrequently in the mountainous districts of the sister island: it is very seldom found beyond the 55th degree of northern latitude. See Aves, Plate VII. fig. 1.

The F. leucocephalus, or the bald eagle, is found in Europe, but more frequently in North-America, and lives on fish as well as flesh. The singular manner in which it procures the former is deserving of notice. It is described by the ingenious and eloquent Wilson in a manner, as his biographer Mr. Ord justly observes, that is perhaps unrivalled by the whole tribe of naturalists, from the age of Pliny to the present day.

"In procuring these, he displays, in a very singular manner, the genius and energy of his character, which is fierce, contemplative, daring and tyrannical; attributes not exerted but on particular occasions; but when put forth, overpowering all opposition. Elevated on the high dead limb of some gigantic tree, that commands a wide view of the neighbouring shore and ocean, he seems calmly to contemplate the motions of the various feathered tribes that pursue their busy avocations below; the snow white gulls slowly winnowing the air; the busy tringæ coursing along the sands; trains of ducks streaming over the surface; silent and watchful cranes intent and wading: clamorous crows, and all the winged multitudes that subsist by the bounty of this vast liquid magazine of nature. High over all these hovers one, whose action instantly arrests all his attention. By his wide curvature of wing, and sud-

den suspension in air, he knows him to be the fish-hawk settling over some devoted victim of the deep. His eye kindles at the sight, and balancing himself, with half-opened wings on the branch, he watches the result.

"Down, rapid as an arrow from heaven, descends the distant object of his attention, the roar of its wings reaching the ear as it disappears in the deep, making the surges foam around! At this moment the eager looks of the eagle are all ardour; and levelling his neck for flight, he sees the fish-hawk once more emerge, struggling with his prey, and mounting in the air with screams of exultation. These are the signal for our hero, who, launching into the air, instantly gives chase, soon gains on the fish-hawk, each exerts his utmost to mount above the other, displaying in these rencontres the most elegant and sublime aeriel evolutions. The unincumbered eagle rapidly advances, and is just on the point of reaching his opponent, when with a sudden scream, probably of despair and honest execration, the latter drops his fish; the eagle, poising himself for a moment as if to take a more certain aim, descends like a whirlwind, snatches it in his grasp ere it reaches the water, and bears his ill-gotten booty silently away to the woods."

This eagle is adopted as the emblem of our country.

F. ossifragus, or sea-eagle, frequents the sea-shore, and subsists principally upon fish; it is nearly of the size of the golden eagle, and is found in many countries both of Europe and America; and is supposed by many persons, and with good reason, to be only the young of the bald eagle; its sight is stated to be equally clear by night and by day. Mr. Barlow relates, that he saw a bird of this species engaged once in a violent conflict in the air, with a cat which he had lifted in his talons, whose efforts, however, were finally too powerful for him, and brought him again to the ground.

F. haliaetus, osprey or fish-hawk, is to be found in almost all parts of Europe and America, on the borders of the ocean, which it frequents for the sake of the fish contained in it, which constitute its principal subsistence, and on which it darts with considerable accuracy; it builds a large nest on trees, and is the most numerous of the larger birds of prey. See Aves, Plate VII. fig. 3.

F. buteo, or buzzard of Europe. The buzzard is abundantly provided with means of defence, as well as attack: but is sluggish and cowardly with all its strength, and will suffer itself to be brought to the ground by a sparrow-hawk, without at all employing those means, which, if fully exerted, would uniformly and inevitably prove fatal to the assailant. The length of the common buzzard is about 20 inches: scarcely any two of the species are marked alike; its food consists of birds, vermin, reptiles, and insects. If the female bird be destroyed by violence or disease during incubation, the male will, it is said, succeed to the charge, and perfectly accomplish it.

F. milvus, or the kite, is about two feet long, and distinguished from the buzzard by a forked tail. In England it continues during the whole year: in various parts of Europe it is migratory, and, as winter approaches, takes its flight to Egypt. It preys chiefly upon small birds, and, from a distance in the air at which it is invisible to the sight of man, will pounce on them with incredible rapidity and fatal precision. It frequently makes attempts and depredation on broods of young chickens, and furnishes hereby to the observer an interesting spectacle of maternal affection and courage in the hen: from these conflicts the kite generally retires worsted, and obliged to await the opportunity, when he may elude the almost incessant vigilance of the dam, or pick up an unfortunate straggler beyond the reach of her superintendance.

F. palumbarius, or the goshawk, is about twenty inches in length; it feeds on mice and small birds, which last it plucks, before it devours them, with great dexterity and neatness; it tears these and other animals to pieces before eating them, then swallows these pieces whole, and, like its congeners, throws up from its stomach the hair or remaining feathers which belonged to them, in the form of small pellets. This bird was formerly in high estimation in England, when the diversion of falconry prevailed, and was trained by very careful discipline to the most accurate obedience of its keeper, and to the most vigorous and fatal pursuit of numerous animals, which, in a state of nature, it left unmolested: even geese and cranes, and also rabbits, it was taught to consider as its prey, and by the judicious application of rewards and punishments, its natural powers attained an improvement, which previously would scarcely have been deemed possible, from any efforts for this purpose.

So difficult was it, however, to meet with that coincidence of circumstances, necessary to produce this great discrimination, tractability, courage, and obedience, that the price of a well-trained cast of these birds was extremely high, and is recorded, in one instance, to have been no less than the immense sum, in those days, of a thousand pounds. The ladies partook in this interesting sport with the keenest relish, notwithstanding its fatigues and dangers. The cultivation of this island has long been so far improved as to preclude the continuance of this diversion, which requires for its purpose a large tract of uninclosed country; in some parts of Europe it is still in use; in China it is practised, occasionally, for the Emperor's amusement, and conducted with all the form and splendour characteristic of Oriental manners. In England the goshawk is to be seen very rarely; in Scotland it is comparatively frequent; in France and Germany, and Siberia, it is far from uncommon.

Various other species of the falcon were in use formerly for the diversion above noticed, especially the jer-falcon, and the kestrel, belonging to the class of the long-winged hawks, and the sparrow-hawk, which belonged to the short-winged class, a class less active and rapid than the former. The sparrow-hawk is the terror of pigeons, partridges, and poultry, and commits its depredations with the most astonishing boldness. The male weighs only five ounces, and the female nine, presenting the strongest known case of this sexual difference.

For the stone-falcon, see Plate VII. fig. 2.

FALCONRY, the art of training all manner of hawks, but more especially the larger sort, called falcons, to the exercise of hawking.

FALKIA, in botany, so called in honour of J. P Falk, professor at Petersburgh, a genus of the Pentandria Digynia class and order. Natural order of Campanaceæ. Borragineæ, Jussieu. Essential character: calyx bell shaped, five-cleft: corolla bell shaped; stigmas orbicular peltate: seeds four-arilled. There is but one species, *viz.* F. repens, creeping Falkia.

FALL, in the sea-langusge, that part of the rope of a tackle, which is hauled upon.

Also when a ship is under sail, and keeps not so near the wind as she should do, they say she falls off; or when a ship is not flush, but hath risings of some parts of her decks more than others, it is called falls.

FALLING-Star, in meteorology, a phenomenon that is frequently seen, and which has been usually supposed to depend on the electric fluid. Mr. Davy, in a lecture delivered a few weeks since at the Royal Institution, gave many reasons against this opinion: he conceives that they are rather to be attributed to falling stones. It is observable, that when their appearance is frequent they have all the same direction; and it has been remarked that they are the forerunners of a westerly wind in our country.

FALLOPIAN *tubes*, two canals of a tortuous figure, but approaching to a conic form, joined to the fundus of the uterus, one on each side. See Anatomy.

FALLOWING, in agriculture, the practice of preparing lands by repeated ploughing, harrowing, &c. so as to render them fit for the growth of grain. Though by the frequent turning of land, and exposing new surfaces of the soil to the operation and influence of the atmosphere, various changes are effected in the earthy particles, yet one great purpose in fallowing is, to destroy more effectually the weeds, which, in consequence of previous mismanagement, and of over-cropping, have increased to such a degree as to render cultivation for grain no longer profitable. Land being allowed to rest for a season from yielding a crop, and being repeatedly ploughed, the soil exposed to the influence of the different seasons, and at the same time completely pulverized, its fertility is again somewhat restored, so that, by the application of a smaller portion of manure than would be otherwise necessary, it is rendered fit for again producing valuable crops of grain or grass. It is universally acknowledged, that all soils, even those naturally the most fertile, are capable of being rendered unproductive by constant and severe cropping, and that the more improper the modes of cropping are, the sooner, and the more certainly, will a comparative barrenness ensue. Hence the propriety of fallowing, where imperfect modes of culture are adopted. Fallowing, in what may be called the infancy of improvements in agriculture, is also essentially necessary. If land be greatly exhausted, no matter by what sort of previous mismanagement, fallowing is the most expeditious, the most effectual, and, every thing considered, the least expensive method that can be adopted, for re-

storing its fertility, and rendering it productive. It is the most expeditious, because it is completely done in the course of one season; whereas several years of culture, and a great additional quantity of manure, would be requisite, were any other less effectual mode of tillage adopted. It is the most effectual, because the farmer has it in his power to destroy every weed, to turn over and expose the soil to the influence of the weather in the different seasons, and also to level and straighten the ridges, drain the land, and remove every obstruction to the introduction of better modes of husbandry, none of which could be so conveniently or effectually performed between the harvest of one year and the seed time of the next. Fallowing is also the least expensive method by which the fertility of land greatly exhausted can be restored, and the only one that can be adopted with a certainty of success, for the removal of every obstacle to the introduction of more perfect agriculture. Manure operates more powerfully, when applied to a field that has been properly summer-fallowed, than when laid on one that has been long under an improper course of cropping. The returns, after fallowing, will be to a certainty greater; and therefore, although the actual expense of fallowing is considerable, yet the crop that succeeds is so much greater as to counterbalance that expense, while those that follow, if properly adapted to the soil, will yield the farmer a proper compensation for his extra trouble and expense. Such is the opinion of Mr. Donaldson, to which Mr. A. Young does not assent; he thinks every advantage is to be obtained by judicious cropping. See Agriculture.

FALSE *imprisonment*, in law. To constitute the injury of false imprisonment, two points are necessary; the detention of the person, and the unlawfulness of such detention. Every confinement of the person is imprisonment, whether in a common prison, or a private house, or even by forcibly detaining one in the streets.

FLAX, in anatomy, a process of the dura mater, placed between the two hemispheres of the brain, and resembling a reaper's sickle.

FAMES, *canina*, an excessive appetite. See Bulimy.

FAMILY, denotes the persons that live together in one house, under the direction of one head or chief manager. It also signifies the kindred or lineage of a person, and is used by old writers for a hide or portion of land sufficient to maintain one family.

Family, in natural history, a term used by authors to express any order of animals, or other natural productions of the same class.

FAN, an instrument used in winnowing corn.

FARINA, a term given to the pulverulent and glutinous part of wheat and other seeds, obtained by grinding and dressing. See Fæcula.

Farina, *fæcundans*, among botanists, the impregnating meal or dust on the apises or antheræ of flowers, which, being received into the pistil or seed-vessel of plants, fecundates the rudiments of the seeds in the ovary, which otherwise would decay and come to nothing. The manner of obtaining the farina of plants for microscopical observation is this: gather the flowers in the midst of a dry sun-shiny day, when the dew is perfectly off; then gently shake off the farina, or lightly brush it off with a soft hair pencil, upon a piece of white paper; then take a single talc of isinglass between the nippers, and, breathing on it, apply it instantly to the farina, and the moisture of the breath will make the light powder stick to it. If too great a quantity is found adhering to the talc, blow a little of it off; and if there is too little, breathe upon it again, and take up more. When this is done, put the talc into the hole of a slider, and applying it to the microscope, see whether the little grains are laid as you desire, and if they are, cover them up with another talc, and fix the ring, but care must be taken that the talcs do not press upon the farina in such a manner as to alter the form.

FARM. See Agriculture.

FARRIER, is the designation of the smith who devotes his attention chiefly to shoeing horses, and to curing them of all kinds of diseases. Perhaps it would be difficult to quote any profession, which could compete with this in self-sufficiency and ignorance; nor would it be easy to estimate the damage done by this tribe, who, having a technical jargon peculiarly appropriated to their presumptuous quackery, continue to deceive a large portion of the community, and generally hold a very improper intercourse with grooms, &c. whence not only expensive jobs are unnecessarily created, but the constitutions of the unfortunate animals which are committed to their

care are often very seriously injured.

We trust that what we shall state relating to the succeding article will contribute to remove the deception, and to enable every person to form some judgment of the ailings to which horses are subject. The term farrier is derived from the French word *ferriere*, which relates particularly to the bag of implements used by the *marechal*, or person who confines his operations to this branch of smithery.

FARRIERY, as may be seen in the preceding article, originally implied nothing more than the art of applying iron, or other substances, to the feet of horses, whereby to defend them from the injuries to which they are subject in travelling on hard surfaces. It was probably owing to the opportunities afforded to the smiths, while shoeing horses, of observing the various diseases of the foot, and consequently of haranguing on the subject, that they, in time, acquired an undue reputation for perfect ability, in not only that particular, but for a general knowledge of whatever related to the animal at large. It will not surprise us to find persons so ignorant as our forefathers of yore were yielding thus implicitly to the presumptuous claims of the farrier; indeed, when we consider how little was known of the art of medicine, and of the very structure of the human frame, it must appear that no other alternative presented itself. But we cannot look back to later dates, without feeling both astonished and ashamed at the indifference, indeed the inhumanity, with which that most useful animal, the horse, has been so long treated.

Happily, however, in these days of improvement, when science has in so many instances removed the mists which clouded the vision of our ancestors, and has proportionally enlarged our ideas, the eye of research has been turned towards the sufferings of the brute creation, and a new profession has sprung up, which not only adds to our stock of medical information, but, while it removes that imputation of cruelty, which had too long stained the character of an enlightened age, promises to reward our kindness and assiduity with the most liberal remuneration. In this we allude to the establishment of a Veterinary College, where, under the auspices of the most distinguished and public-spirited characters, the whole art of medicine and of surgery, so far as they relate to horses, &c. together with the true principles of shoeing, and of treating horses while in a state of disease and of health, are publicly taught by a surgeon, who has made them his study, and who has the designation of Professor of the Veterinary Art.

Such an establishment, which was not novel on the Continent, was truly a desideratum; like most of our important improvements, it was first proposed and acted upon by a foreigner, Monsieur St. Bel, who, in the year 1788, came over from France, and, observing the lamentable want of veterinary knowledge, published proposals for the establishment of a college. The matter was not, however, noticed, until the Agricultural Society of Odiham, in Hants, seeing the vast benefit which must inevitably result from such an institution, agreed to support Monsieur St. Bel. He was accordingly nominated to the professorship, under the patronage of many eminent characters. The Duke of Northumberland was elected president; and the list of vice-presidents was graced with the names of earls Grosvenor, Morton, Oxford, and Rivers, Sir George Baker, Sir T. C. Bunbury, Sir William Fordyce, and the celebrated John Hunter, Esq.

Vicinity to London being an important object, and a pure air no less indispensable, Pancras was fixed upon for the scite of the college. Its success, however, was not, in the first instance, much to be vaunted; indeed, its stability became somewhat doubtful, owing to a variety of causes. The fact seems to be, that St. Bel, though a perfect enthusiast, and to a certain degree skilled in the veterinary art, had not that complete acquaintance with the subject which so conspicuous a situation imperiously demanded; he was also deficient in that peculiar ductility of disposition, and that accommodation to the opinions of others, which in every instance are prepossessing, and, to a man in his situation, were indispensable. He died in 1793, and Messrs. Coleman and Morecroft were appointed joint professors. Both these gentlemen appear to have been highly qualified for the pre-eminent situations they held; Mr. Coleman being a surgeon who had distinguished himself by a work of great merit; and Mr. Morecroft being a medical gentleman who had visited the continent, for the purpose of acquiring as complete an insight into veterinary operations as the schools in that quarter could furnish. The latter, however, ultimately retired, and left Mr. Coleman to fill the professor's chair, which he does

with infinite advantage to the public, and with no less credit to himself.

A sum is allowed annually by Parliament towards the support of the college, which also derives some aid from the fees of students, and from subscription. The donation of twenty guineas makes a subscriber for life, and the payment of two guineas yearly gives the same title for that term. In either case, the privilege of sending two horses to the veterinary hospital, free of all charges, except for keep, is thus acquired. His Majesty has given considerable importance to the institution, by requiring that all veterinary surgeons employed in the army should have passed examination at the college; and he has eminently served the whole of the cavalry corps, by conferring on those surgeons the rank of commissioned officers. The various lecturers on medicine and surgery, who have so handsomely contributed their efforts towards the success of this important establishment, have on all occasions vied in promoting its welfare, and in extending its influence, by allowing the students to attend at their respective lectures, free of expense, those liberal professors have essentially served the institution.

We shall now endeavour to lay before our readers a concise account of the present improved mode of shoeing, and of treating diseases, as practised at the college.

The first object which comes under notice is, the mechanical operation of shoeing. It would be entering on too extensive a field, were we to enumerate the various forms that have been recommended, together with the reasons assigned for the supposed superiority of each: we must content ourselves with describing the method now in use.

Mr. Coleman has the shoes made three times as thick at the toe as at the heels, because they wear more forward than behind. By this means the heels are less oppressed with weight, and the frog is allowed to come down to the ground: a matter of extreme importance. The nails are all placed forward, four on each side, but not approaching too near the heels, that they may not obstruct the elastic powers of those parts. The old method of fullering, *i. e.* making a groove in the shoe, being found injurious, by often breaking away the heads of the nails, they are now counter-sunk in conical or wedge-shaped holes, so that they may be driven up close to their thickest parts, and be out of the way of accident. By this means the nails and shoes appear as one body, and always wear together.

For horses which go in shafts, or are used in hunting, it is usual to make shoes with only one heel, which should be outward. The horse's heel must be rather lowered on that side, and the inner heel of the shoe somewhat thickened, so as to balance, and bear equally. By this easy precaution a good footing is obtained, and cutting is effectually prevented. The best breadth for the shoe of a medium sized horse is said to be one inch at the toe, and three quarters at the heel; the weight about eighteen or twenty ounces. Light saddle-horses should not have shoes exceeding sixteen ounces; and, unless local circumstances prevail, twelve ounces will be generally found preferable.

In order to fit the shoe without causing the horse to stand too much on his heels, the under part of the crust, or wall of the hoof, is pared away, to receive the excess of thickness in front; for the bottom of the shoe ought to be perfectly flat, without any stubs or calkings in front. Paring away the heels is a most destructive practice, except in case of absolute excressence in those parts; nor should the bars (or diagonal ridges) that extend from the heels to the frog, or central projection, ever be cut more than is absolutely proper for the purpose of keeping them in a clean and healthy state. When it is considered how much the elastic power of the heels depends on the bars, which act as a spring between them and the frog, it must appear unreasonable that they should be shaved away, as is too often done by farriers, under the idea of preventing corns: though by such a process corns are created. A good open heel is the indication of a powerful foot; hence the sides of shoes ought not to be much contracted. When the heels are tender, what is called a bar-shoe ought to be applied. By this simple contrivance, which saves them from pressure on uneven surfaces, many a horse has been found serviceable, that must else have been condemned to the slaughter-house.

The frog appears to be the part on which the horse chiefly depends for a spring, or resistance, at the bottom of his foot. If this part does not touch the ground, the whole motion will be derived from the upper parts of the limb, and a very uneasy gait will inevitably follow. This points out the necessity for leaving it fully at liberty to come in con-

tact with the ground. Some horses have been ruined by inattention to this point, and some few have naturally a defect in that part. To provide against such circumstances, Mr. Coleman uses an artificial frog, which receives the pressure, and gives the greatest firmness to the tread. It is usually but a temporary expedient, as the frog commonly grows, and renders the substitute unnecessary.

Having given a general, but very correct outline of the process of shoeing, we shall proceed to a brief statement of the various diseases, &c. which usually come within the farrier's notice, in their alphabetical order.

Anasarca, or dropsy of the skin, is generally called the water farcy, owing to the fluid being dispersed through the cellular membrane of the skin. It is known by pits remaining after the skin has been pressed by a finger; and, usually, proceeds from a deficiency of the absorbents, or an excess in the inhalents; from jaundice, hydatides, or previous inflammation. The cure is usually effected by stimulant applications, and by diuretics; smart friction, and gentle exercise, if long continued, are highly serviceable; the food should be nourishing. When only the lower extremities are diseased, rollers dipt in spirits, or in oil of turpentine, will generally remove the complaint. Horses are most subject to anasarca at spring and fall, when shedding their coats. If eruptions take place, the cure is much facilitated: but they ought to be mildly treated, and suffered to heal voluntarily.

Ascites, or dropsy of the belly, may be known by the local swelling, which, when gently struck, undulates so as to be sensibly felt by the hand. This complaint arises from the causes just described, and occasions considerable thirst, short breath, and an obvious diminution of urinary discharge. To cure this complaint, every means should be used for strengthening and accelerating the secretion in general, and for promoting the circulation of the blood and fluids. Drastic purges, diuretics, sweating, and in some cases mercury, rarely fail to render important service. This disease, however, is apt to recur, unless the constitution be completely fortified, and the general habit brought into due state.

Bleeding, or blood-letting, should be performed with a lancet of a suitable size; the fleam being very uncertain on large rolling veins; and in the thigh, &c. absolutely dangerous, often producing violent inflammation, and sometimes incurable lameness. The jugular-vein is usually opened in common cases; especially when the head is the seat of disease: in other instances the plate-vein, or that within the thigh. In the first case, a piece of thin cord should be passed round the horse's neck a little above the withers, and the part be wetted, so as to shew the vein. The quantity must depend on the case; but one or two quarts for periodical bleeding are enough to be drawn from a full-sized horse in good condition; in some cases, much greater quantities must be taken. When the bleeding is to be stopped, slacken the line, and pass a pin through the lips of the orifice; then taking a few hairs from the tail or mane, or a piece of thread, pass over the head and point of the pin therewith, in an alternate (*i. e.* a figure of 8) direction, and make fast.

Breaking down, as it is usually called, proceeds from a rupture of the suspensory ligaments, and chiefly happens to young horses in training. In this instance the fetlock nearly touches the ground, but the foot can be bent when raised. Few cures are made, though much palli. ation may be effected, by reducing the inflammation in the first instance, raising the limb, especially the heel, so as to throw the weight on the other leg, and to relax the part. By this precaution, added to bleeding, purging, and the use of bracing applications, or eventually by firing, the limb may gradually become equal to very light exercise; but never can be depended upon, or be deemed sound.

Broken wind, this complaint is supposed to proceed from a rupture of the cells in the lungs: in the moment of the wind's being expelled from them a check occurs, which gives occasion to a second effort, thus causing a division in the sound: hence the term under which this complaint is known. The causes of this rupture are numerous, but the following are among the most frequent; viz. catarrhs, working after a full meal, or after drinking freely: girthing too tight: being suddenly put into hot stables after standing out in a cold air, &c. &c. This complaint, we belive, does not admit of a perfect cure; but, by much care, may be greatly relieved. The food should be compact and nutritious, such as corn and old hay. Carrots are excellent in this case, as are parsnips, and beet roots; probably on account of the saccharine matter they contain. We have heard, that molasses has been given in the water,

(which should be in very small quantities,) with very great success. Some have used tar-water; others praise the effects of lime-water; but the greatest dependence should be placed on very sparing supplies of substantial food. The exercise ought to be regular, but never beyond a walking pace. If the symptomatic cough should prove troublesome, take away about three quarts of blood every third day.

Canker, is a sharp humour, called the thrush, which, in some instances, attacks the sole of the foot, and does inconceivable mischief: if neglected, it will in time destroy the whole foot. The appearance of this complaint is decided, it rising like a fungous excrescence, covering the diseased part, and must be completely extirpated before a cure can be expected. Cut away freely from the horny sole, and dress the surface with a solution of lunar caustic dipped in tow. Fasten on well, as much depends on pressure: if the shoe be ribbed with cross bars, all the better. Raising the opposite foot, so as to make the horse bear on the cankered one, will facilitate the remedy.

Catarrh, often called morfoundering, is usually the effect of cold, and produces the same symptoms as among the human species. Sometimes acute fever attends; in such case the greatest service will be rendered by warm diluting drinks; or eventually by mild purges, aided by bleeding. Warm clothing, and a warm mash suspended in a nose-bag, will afford great relief. The glands should be covered with flannel, moistened in a mixture of hartshorn, one part, and olive oil, four parts. Avoid whatever is heating, and be careful to keep the bowels open, the skin moist, and the bedding abundantly supplied. The stable ought not to be kept too hot, as it would render the horse tender in his lungs, and perhaps induce to broken wind. Encourage the running at the nose: if obstructed, the glanders would probably ensue.

Corns, consist of extravasated blood, or lymph, collected between the crust, or wall of the hoof, and the bars. These, in general, proceed from bad shoeing, especially from the heels being contracted, by hard labour, and improper pressure. Cut away as far as the extravasation, and apply a pledget of lint, dipped in tincture of myrrh, or in balsam of Peru. When the corn has been cut, the horse should be turned out to grass, without shoes, if practicable; or if his labour cannot be dispensed with, let a chambered shoe be put on, so as to avoid pressing the part.

Cough, when this is symptomatic, it will disappear as the complant which it attends may be removed; but if chronic, the cure will be uncertain, difficult, and tedious. The following cheap recipe has often proved serviceable. Tar eight pounds, lime twelve pounds, water six gallons; mix them well, and give a quart every morning.

Cracks, in the heels, usually proceed from a gross habit, or from filth, or from washing the legs without rubbing them dry. Sometimes the cracks discharge a quantity of sharp ichor, which must be frequently removed, or severe excoriations may follow. Wash with strong soap-suds, lower the food, give mild purges, or diuretics, and, if the habit be full, bleed freely. Avoid all greasy applications, and allow no ligatures: wash often, and dry carefully.

Diabetes, or a profuse discharge of urine, is generally considered a fatal disease: it is often brought on by violent medicines, especially diuretics, which should be carefully avoided in this complaint. Bad food is also a frequent cause. The surest remedy, if any can be so called, is to feed the horse with fresh blood, or with strong meat broth; avoiding vegetables, unless it be good wheaten bread. Opium, bark, chalk, and such tonics and correcting medicines, as also the volatile liver of sulphur in small doses, will be usually found to give relief: though a perfect cure is scarcely to be expected.

Diarrhœa, or looseness, often follows the injudicious use of strong medicines; and especially where astringents have been given. The complaint is somewhat critical; in which instance it should not be checked, but treated with copious diluents of a soft kind. Sometimes hard labour, in bad weather especially, with bad stabling, or bad food, will induce this complaint, which is to be treated with great caution; lest it should degenerate into dysentery, inject the anodyne clyster, and give the following drink twice daily: opium two drachms, ipecacuanha three drachms, prepared chalk four ounces, thin starch a pint: mix, and drench with it. If it does not answer the intention within four days, at farthest, give alum whey, as recommended for the dysentery. Avoid all astringents, but give no cold drink, and encourage sweat by means of good clothing. Litter well, and

allow a moderate current of air, if the stable be hot.

Dysentery, or flux, commonly called molten-grease, is a most painful and dangerous complaint. The animal is usually afflicted with tenesmus, and voids a great quantity of slimy mucus, and but little dung. This disease arises from a great variety of causes, and in some seasons is said to be epidemic.

The safest purge, in the first stage, is about a quart of castor oil. If that does not remove the fæces, give calomel four drachms, gum arabic two drachms, with honey enough to form a bolus. On all occasions ample clysters of gruel, linseed water, &c. should be frequently injected. In obstinate cases administer the following: take ten poppy-heads, boil them in six quarts of water till only a gallon be left, add starch enough to soften into a thin mucilage, throw up three or four times daily. Internally the following may answer. Opium two drachms, ipecacuanha four drachms, nux vomica, in powder, one drachm, port wine one quart. Mix, and repeat morning and evening. Let the horse be well clothed, so as to keep his skin moist; the stable should not be hot. If the dung smells offensively, the stable must be fumigated and kept extremely clean.

Farcy is easily removed in its first stage, when it consists of merely a superficial inflammation, but if suffered to proceed, it quickly taints the circulation, and often induces the glanders. It is highly infectious; in the first instance each bud or swelling should be burnt with a hot iron, or by caustic; but when the blood is infected, (which is known by the buds being ulcerated, and a discharge at the nose,) the strongest medicines must be used. Let a scruple of corrosive sublimate, levigated, be mixt with butter, or in gruel, and given in two doses; *i. e.* night and morning. If the bowels should be affected, the dose must be less; but if no uneasiness be produced, it may be increased to half a drachm, or even to two scruples. If the sublimate should prove too powerful, substitute a drachm of calomel, night and morning. Green food is peculiarly serviceable. Destroy the clothing after a cure; or the disease will be regenerated.

Fever must always be traced to its cause, and its particular species must be ascertained, before medicine is given. If the common inflammatory symptoms are indicated by the pulse, the eyes, and the general action of the horse, bleeding, to the extent of three or four quarts, according to the size and condition, ought to be immediately practised: after this, rake and throw up the following clyster: gruel, or broth, 3 quarts; common salt (or Epsom salt, if at hand) 4 ounces; brown sugar, 4 ounces, and sweet oil, or melted butter, or lard, 4 ounces; administer blood warm, in a gentle manner. Give the following twice, daily; emetic tartar, 2 drachms; nitre, 1 ounce; mix in a pint of gruel, or form into a bolus with honey. Avoid whatever is heating; let the animal be kept in a cool stable (not windy or damp) and clothe moderately. Let him have plenty of warm drink of a diluent kind; such as bran-water, hay-tea, scalded malt, or warm ale; which last ought, however, to be very mild. Leave a little very sweet hay for him to pick at; if at a proper season, green tares, or other young artificial grass, may be given in small quantities. Avoid tight girthing, and allow plenty of bedding. Sprinkle the stall occasionally with hot vinegar, and remove the dung as soon as it falls. If cold fits intervene, use warmer clothing, and let friction, with a soft brush, be persisted in, until warmth is restored. Above all things keep the body open, and avoid every thing that frightens or irritates: if the horse will lay down, it will favour the cure.

When a fever is symptomatic, the cause must first be removed; in the meanwhile soothing treatment should be resorted to, and palliatives be principally used. In this we allude to diet, &c. as detailed in the foregoing paragraph. When the fever runs very high, and that bleeding cannot be attempted (either at first, or in repetition) clysters must be frequently given, and rowels may be made in the breast and thighs.

When the fever is equivocal, or when it is decidedly of a malignant species, such as the typhus, or epidemic, which in some countries is by no means rare, though uncommon with us, if the horse be in a robust state, bleed copiously; but if emaciated, or of a weak frame, avoid that evacuation. Wash the body with warm vinegar, in which aromatic herbs have been boiled; sprinkle frequently with the same; remove the dung instantly, and change the bedding twice or thrice within the day. Burn nitre every half hour, so as to occasion a thick smoke, and let a piece of touch-paper be always smothering in a corner of the stable, which ought to be very cool. Keep the body open with antiseptic

purges, and use little clothing. If a critical purging should come on, by no means check it; encourage every sore which may appear, and open rowels in various parts. This complaint being highly infectious, no other horse should be allowed to stand within the same area; in fact, horses labouring under the typhus fever should be removed to some distance from other animals, whether horses, horned cattle, &c.; the infection being very apt to reach them.

Fistula, being a complaint absolutely requiring the aid of a surgeon when in *ano*, *perineo*, &c. we refrain from stating any thing on that subject.

Fistulous withers will be found a very troublesome complaint; and under the hands of a common farrier will seldom be cured, without considerable delay, and great risk. We advise great cleanliness, and that the part should be laid open, if the situation may admit: or, at all events, that a seton should be passed through the bottom of the sore, whence the matter might be discharged. Apply light pledges of lint, just to keep the parts open; and when about to heal, which may be known by the granulations, &c. be cautious not to allow any pressure. If any of the dorsal spinous processes be tainted, exfoliation will take place: encourage the efforts of nature in that respect. Keep the body open, and let the diet be soft and cooling; allow free ventilation, and approach the animal gently. Sudden starts, and motions arising from fear, often do incalculable mischief in this complaint; which may be speedily removed, when timeously and cautiously treated.

Founder, has usually been mistaken for a disease of the loins or of the chest; but where its seat is forward, the fore feet will be found injured; in the former case the hind feet: this may be easily ascertained by observing whether the horse seeks relief from bringing the hind legs forward (as he stands in the stable) to support the fore quarters, or keeps the fore legs inclined considerably backwards, to support the hinder quarters: thus endeavouring to take the weight off the tender parts. When all the feet are affected, the horse lies down, and is unwilling, or perhaps unable, to rise. This is usually a very troublesome complaint, and requires very copious bleeding, and every attention to ease and rest. The shoes ought to be taken off, and very soft litter be allowed, and frequently tossed up with the fork, to keep it from caking. Bleeding at the toes rarely fails of giving great relief; letting the blood flow freely. Endeavour, by all means, to prevent the collection of matter, as that always injures; indeed, after once suppuration has taken place, weakness, if not rottenness, will ensue in almost every case. Purge well, and keep the feet cool by the frequent application of salt and water, or sugar of lead in water, or sal-ammoniac and vinegar. Pare away the crust, so as to liberate the foot from its usual constriction. When recovering, we would recommend to turn the animal out into a rich soft paddock, if the season permits; or into a soft straw yard: the former is best, on account of the diet. Allow no corn, unless where the horse is extremely weak; and then scalded malt, &c. will answer best. In very bad cases, some have taken up the lateral arteries; but such seems to be a desperate course, and should never be practised where any hope remains of success from milder treatment. When reduced to that extremity, the beast can be of no value.

Fractures and *laxations*, are subjects for the introduction of a surgeon; in most instances cures might be effected, provided the horse could be slung, so as to take the pressure entirely off from the limb. Iron frames, and very stiff splents, are sometimes used; but cannot always be had; neither are they applicable to every case. Nature in time will unite the bones of a simple fracture, after they have been set; but in general a callous protuberance is seen, which renders the animal less saleable; though the limb may be as serviceable as ever. We think it absurd to shoot a horse merely because he has broke a bone, which, by a little care, might be perfectly restored.

Grease is generally the effect of too rich food with little exercise; or it may be induced by bad standing, or by excess of labour; it is most frequent, and most difficult of cure, in very long limbed horses. Washing the legs without drying them is very apt to produce this disease, which is equally disposed to recur. If grease proceeds from redundancy, bleed, purge, and use gentle exercise, with moderate friction. When from weakness, or over labour, allow rest and nourishing food, giving good standing, and preserving perfect cleanliness.

Gripes have remissions of pain, which distinguish them from inflammation in

the bowels, as does the disposition to roll on the back. Costiveness, bad food, drinking while warm, standing in the cold, especially after exercise, all cause this complaint. To cure it, rake well, throw up clysters as warm as can be borne, and in large quantities. If the pain be very acute and obstinate, bleed copiously, and give a lump of opium, about the size of a large hazel-nut. But this must be done before any symptoms of inflammation appear. Foment the bowels with hot water, applied by means of blankets dipt therein. Give this draught as soon as possible : *viz.* castor-oil, one pint; oil of peppermint, one drachm ; mix them with the yolks of two eggs ; then add half a pint of water. If the bowels have not been well opened, let the following be given. Calomel, half an ounce ; gum-gamboge, one drachm ; Castile soap, half an ounce ; made into a bolus with honey, and given at night ; keeping on warm clothing, and cautiously avoiding a draught of wind.

Gutta Serena, or *glass-eyes*, being absolutely incurable in horses, we shall not treat of it here, but refer to that head for a description of the disease, as it affects the human eye.

Hepatitis, or inflammation of the liver, is usually induced by a morbid state of the parts secreting the bile, and may be known by a yellowness of the eyes and mouth, attended with considerable fever: in severe cases, the horse is sometimes stiff in the off shoulder. Bleed freely, and blister the sides, applying numerous rowels underneath. Rake, and clyster; then purge well, by giving the following bolus, night and morning, till it operates freely. Calomel, half a drachm ; aloes, one drachm and a half; Castile soap, two drachms ; mix with honey.

Hydrophobia is incurable ; however, if a large piece be taken out as soon as the horse has been bitten, or a fire-brand be quickly applied so as to burn a deep hole, or that lunar caustic be used, the animal may be saved ; but such cannot be done in every part. Purge well, and administer mercurial preparations, so as to affect the system forcibly for a few days; gradually abating for a month, or more ; if rapid symptoms appear, the horse should be instantly destroyed.

Jaundice may exist with or without any obvious inflammation of the liver; but should, for the sake of safety to the animal, always be considered as connected with hepatitis (which see.) If the symptoms be not urgent, the bleeding may be omitted ; but purge well.

Inflammation, in whatever part, is generally the index to blood letting, either by opening a vein, by cupping, or by some other means. But local inflammations which seem to be critical, and push forward to suppuration, should rather be encouraged than resolved, unless they settle upon some part endangering the life. When the brain is enflamed, the lancet must be freely used, as must the blistering ointment and purges, together with whatever may tend to lessen the complaint in that part. The eye must, when in a state of irritation, be kept cool, and the habit lowered. Mild solutions of white vitriol, added to a few drops of extract of saturn, should be applied, in the form of poultice, cold, and frequently. When the stomach is inflamed, the horse should lose blood, and be clystered occasionally with soft cooling liquids. In case of inflamed bladder, diuretics should be avoided ; clysters should be occasionally administered, and mucilaginous, soothing drink be liberally given ; such as decoction of mallows, gum-arabic, linseed-tea, barley-water, &c. with regard to an inflammation of the liver, we refer to hepatitis in this article. When the kidneys are inflamed, the treatment should be as in diseases of the bladder ; observing, that the animal ought to be kept very low, after ample evacuations, both by bleeding and gentle purges ; and that diuretics are highly prejudicial.

Lampes, is a swelling of the bars in the roof of the mouth, chiefly in young horses. But as, in such, the bars are always large, and appear to be swelled, be cautious in ascertaining that they really are so. When such is the case, by no means burn with a hot iron, as farriers too often do, but rub with alum and honey ; if they do not subside, you may scarify the part very slightly with a sharp instrument, guarded with tow, &c. near its point, so that you cannot, in case of accident, do injury by making too deep a wound.

Lethargy, is often very slow in its approach, but sometimes equally rapid ; in the latter instance rather tending towards epilepsy. It is occasioned in either case by two great a determination of blood towards the head. Bleed freely, unless when the debility is great ; open the body by active purges, rake, and clyster, and endeavour to excite perspiration. Give the following : nitre, three drachms ; resin, three drachms ; cream of tartar,

three drachms; all finely powdered, and mixed with honey into a bolus: repeat every morning, until the discharge of urine is abundant.

Mallenders, and *sellenders*, are scurfy eruptions about the knee, discharging a sharp ichor: they bear the first designation when within the front bending of the hock, the latter when they appear at the back of it. Wash with soap-suds, and apply the following: white vitriol, half a drachm; sugar of lead, half a drachm; tar one ounce; mix, and rub in gently.

Mange, commonly arises from filth, or from poorness of condition, and is extremely infectious. Wash well with soap-suds, and apply the following: common brimstone, levigated, eight ounces; of alum and white vitriol each five drachms; horse turpentine, three ounces; lard, half a pound; mix, and rub frequently.

Pole evil, arises chiefly from friction of the collar at the back of the ears, or other such causes: it often forms a tumour, which must be brought forward, unless by blistering, &c. the fluid can be removed. Take care to open below the abscess, else there will be danger of sinuses. The sore is often extremely difficult to heal, and requires much patience: it will, however, generally yield to cleanliness, and due discharge downwards, by means of a seton smeared with mild blistering ointment: this ought to be kept in until the cavity is grown up, and in a manner grasps the seton.

Quittors, commonly are produced by the lodgment of filth about the coronet and surrounding parts: they should never be burnt, as is often practised by common farriers; but be kept very clean, and dressed twice daily with dijective ointment. If carbuncles, or proud flesh, should arise, take them down by means of lunar caustic. These sores are usually very tedious; but should not be hurried, as they are apt to break out afresh, or to run among the bones of the foot, when prematurely dried. Wash frequently with soap-suds, and put pledgets of lint, steeped in spirits of turpentine, until the sores appear clean and healthy.

Ring bone, is an exostosis, which partly surrounds the coronet: this, together with *splents*, *curbs*, *bone-spavins*, &c. may sometimes be cured by early attention; but when suffered to stand long, cannot be removed except by absolute force, such as sawing or chisseling them off. A strong preparation of corrosve sublimate, added to Spanish flies and Venice turpentine, and mixed with hog's lard, will often dissolve a ring bone, &c.; but much time is generally required to complete a cure.

Stag-evil, is properly the *tetarsus*, or locked jaw. This is often caused by sudden changes from heat to cold: generally speaking, the cure is very uncertain; but it will chiefly depend on opium, the warm bath, and other antispasmodics. Sometimes the sudden application of cold water in great quantities has been serviceable: friction of turpentine oil or spirits generally proves useful, as does a clyster made with 2 *oz.* of spirit of hartshorn, 4 *oz.* of oil of turpentine, and the yolks of three or four eggs; mixed with a quart of strong ale and gin. It is a great object to promote urine, sweat, &c.

Staggers, or *phrenzy*, is supposed to be a variety of the sleepy staggers, vertigo, or lethargy; only that in this instance the pressure on the brain is extreme, and the animal rendered outrageous. The causes are various; but for the most part this distemper arises from the critical termination of some other inflammatory disease. Sometimes it proceeds from a sunstroke, and has been known to arise from the vicinity of putrid matter: being suddenly changed from poor food to rich nourishing diet is a very frequent cause. To effect a cure, the horse should be bled copiously, from three to four quarts every eight hours, until the symptoms abate. Blister the head and neck with Spanish flies mixed in spirits of turpentine, rake well, and administer a strong clyster, so as to excite considerable discharge of excrement. Let the stables be very cool and be sprinkled with hot vinegar. If possible to get a bolus down, let the following be given: calomel two drachms, aloes six drachms, Castile soap two drachms, mixed with honey. Allow very little drink. In desperate cases sling the horse, and throw cold water over his head and neck.

Stones in the bladder have been removed by cutting, the same as is practised when they form in the human bladder; but this is a very uncertain operation with cattle. When in the kidnies, stones may sometimes be brought down by strong diuretics; but when so situated, the animal generally lingers a long time, and dies in great agony, perfectly emaciated. Horses also have stones occasionally in the intestines, generally in the cœcum, or blind gut. These induce frequent colics, and as they grow occasion much pain: unfortunately we know not of any means for their expulsion, or

for their dissolution. Mares have been known to void great quantities of small stones, like pebbles.

Strangles rarely attack horses after completing their sixth year. This curious complaint has been compared to various diseases incident to the human frame, however not with perfect propriety. It usually begins with a fever, a cough, a running at the nose, and a swelling of the sub-maxillary glands. If unheeded, those glands will suppurate, rendering the cure very tedious, and in some degree dangerous. Repel, if possible, by copious bleedings, opening the body, exciting perspiration, and by gentle diuretics. Give the following, night and morning : nitre six drachms, cream of tartar six drachms, emetic tartar a drachm and a half, warm gruel one quart. Often great advantage is derived from blistering the throat, and from rowels in the chest. Strangles are supposed to be infectious : but we believe that point has never been fully ascertained. It may, however, be prudent to obviate any hazard of contagion.

Swelled legs usually proceed from weakness, and are very frequent after long indispositions, during which horses could not be duly exercised. Bleed freely, if the horse be in good condition, and lower his diet ; use gentle exercise, and rub the part with flannel, or a soft brush : put on a stocking at night dipt in spirits of turpentine, with a little goulard mixed. As the parts diminish gradually apply elastic rollers : but take care not to impede the circulation. Give very mild purges and diuretics, observing to keep the body gently open. If the complaint proceeds from debility, feed well, and proportion the exercise to the animal's powers : never fatigue him. But friction will on all occasions be found the safest and the most effectual remedy. The stables should be kept cool, and sweating should be particularly avoided, since it would increase the complaint. In some strong habits, rowels in the thighs may be advantageously made.

Thrush, or *running-thrush*, is a discharge from the sensible frog, which soon becomes deeply diseased, if the pressure, &c. which occasioned the complaint, be not removed. It chiefly takes place in narrow heels, especially where the frog has been cut away, and the heels left high. The running ought to be dried, taking care to bring the frog into action, by lowering the heels gradually, and bearing upon it by means of a bunch of tow. Use this wash frequently, as warm as it can be borne : tar two ounces, oil of vitriol six drachms. Gentle purges and mild diuretics will greatly aid towards a cure, if the habit be full, and the discharge considerable. Horses that have bad standing are very subject to this complaint : in fact, dirty, damp stables give birth to an infinity of diseases.

Ulcers invariably require soft dressings, and that their edges should be kept low, and free from callous or horny matter.

Dress often, and in case of a sinus be careful to have the vent downwards, so that the discharge may be free. We have not any complaint more various than this, nor one more difficult to heal. Indeed, in some instances, that should not be attempted. Cleanliness and mild treatment are indispensable. If fungous flesh should arise, or the edges become hard, touch with blue vitriol, or with lunar caustic, and make way for the flesh to granulate, and for the skin to collapse. When the habit is foul, topical applications alone will not answer ; alteratives must be given, and the diet be such as may check the acrimony. When the wound cicatrizes, apply a little lard very gently to soften the skin ; and if the flies are troublesome, mix a very small quantity of tobacco in the lard.

Warbles, from under the saddle, in consequence of unequal pressure. Perfect rest is the best remedy ; but a solution of sugar of lead in vinegar will greatly promote dispersion. If the warbles become firm, (*i. e.* sit-fasts) blister them, or, if necessary, let them be carefully extirpated by the knife.

Wind-galls must be removed by firm pressure on a bolster, that immediately sets upon the swelling: when subdued, the part should be fired, to prevent recurrence of the complaint. The sweating blister, made by steeping Spanish flies in vinegar, often has a fine effect, as will any preparation that causes speedy evaporation ; but the compress is what we chiefly advise : for unless the parts be brought together by pressure, the object will rarely be attained.

Worms frequently cause extreme indisposition before their existence is even suspected : many horses have, indeed, died in consequence. It is proper therefore to state, that when a horse rubs his tail, and that a yellow matter appears at times about the anus, worms may be suspected ; especially if he eats heartily, yet has a staring coat, and does not thrive ; or that he stands with his hind

legs straddling, has slight attacks of gripes, and frequently turns his head towards his belly, which commonly appears large and low. Bots may often be found among the dung; these are very tenacious of life, and resist most of our strong vermifuges. Common salt is one of the most powerful remedies; but subjects the horse to considerable inquietude. The root of the male fern, levigated and given fresh, is highly extolled, as is soot also. But we believe that strong doses of calomel and gamboge will be found the most efficient, provided they be persevered in so as to scour for a number of days, or even perhaps a fortnight, in succession; but this must greatly depend on the condition and constitution of the horse. The teretes, or long round worms, are commonly white, about ten inches in length, and require very strong purges to dislodge them. The ascarides, which are very small worms, scarcely longer than a common needle, are not so bad as the preceding, in their effect on the intestines, but give considerable uneasiness. We recommend the continued purge, as affording the best prospect of expulsion.

Under the article EQUUS the reader will find what appertains more particularly to the nature of that useful animal: we shall conclude this with strongly inculcating the expediency of avoiding communication with farriers, and in advising the introduction of regular medical or surgical aid, whenever horses suffer under such indisposition, as cannot be removed by the cheap and simple recourse to good bedding, ease, moderate warmth, generous diet, suited to the case: and where there appear inflammatory symptoms, to bleed to the amount of two, three, or even four quarts, substituting diluent beverage, such as warm hay or linseed-tea, or scalded bran, or malt, in lieu of more substantial food. By such attention, and by forbearance from violent or harsh measures, we have seen horses speedily recover from complaints, that, under the farrier's auspices, would have induced long disease, and a long bill. There will be found in every town some person capable of giving advice at least; and in most places some one of the profession will be found willing to take charge of a sick horse. Formerly, indeed, such a request would have appeared an affront; but in these more enlightened times, that apprehension need not be entertained: indeed many eminent surgeons pride themselves on a familiar acquaintance with veterinary subjects. Perhaps we may be right in observing, that the designation of *horse-doctor* being banished from our country establishments, to make way for the more respectable title of *doctor of horse*, has not a little contributed towards the present liberality of sentiment to this useful profession.

To such readers as may be desirous of obtaining a full acquaintance with the subject, we recommend personal application to Mr. Coleman, and that they subscribe to the college fund. By such means they will derive the utmost advantage from the liberality and abilities of that gentleman, and gradually become competent to the treatment of the most ordinary class of accidents and distempers. Mr. Coleman's work will also be found a cheap and highly useful member of the library.

FASCIÆ, in astronomy, certain parts on Jupiter's body resembling belts or swathes. They are more lucid than the rest of that planet, and are terminated by parallel lines, sometimes broader and sometimes narrower. M. Huygens observed a facia in Mars much broader than those of Jupiter, and possessing the middle part of his disk, but very obscure.

FASCINES, in fortification, faggots, of small wood of about a foot diameter, and six feet long, bound in the middle and at both ends. They are used in raising batteries, making chandeliers, in filling up the moat to facilitate the passage to the wall, in binding the ramparts where the earth is bad, and in making parapets of trenches to screen the men.

FASCIOLA, in natural history, *gourd-worm*, a genus of the Vermes Intestina class and order. Body flattish, with an aperture or pore at the head, and generally another at a distance beneath, seldom a single one. About fifty species have been described. They are divided into different sections, *viz.* those infesting mammalia, birds, reptiles, fish, and worms; among the first is F. hepatica, fluke or gourd-worm; which is found in the liver of sheep, and is often vomited in brooks, and is generally found fixed by a pore at the extremity, and another in the middle of the abdomen, and occasions dropsy, and the disorder which is called the rot. The body of this animal is about an inch long, broader on the fore-part, and terminated by a tube; the back marked with,

about eight longitudinal furrows, in two series.

FAT, an oleaginous or butyraceous matter, secreted from the blood, and filling up the cavity of the adipose cells. See ANATOMY.

FATA *morgana*, a very remarkable aerial phenomenon, which is sometimes observed from the harbour of Messina and adjacent places, at a certain height in the atmosphere. The name, which signifies the fairy morgana, is derived from an opinion of the superstitious Sicilians, that the whole spectacle is produced by fairies, or such-like visionary invisible beings. The populace are delighted whenever it appears, and run about the streets shouting for joy, calling every body out to partake of the glorious sight. This singular meteor has been described by various authors; but the first who mentioned it with any degree of precision was father Angelucci, whose account is thus quoted by Mr. Swinburne in his tour through Sicily: "On the 15th of August, 1643, as I stood at my window, I was surprised with a most wonderful delectable vision; the sea that washes the Sicilian shore swelled up, and became for ten miles in length like a chain of dark mountains; while the waters near our Calabrian coast grew quite smooth, and in an instant appeared as one clear polished mirror reclining against the ridge. On this glass was depicted, in chiaro-scuro, a string of several thousand of pilasters, all equal in altitude, distance, and degree of light and shade. In a moment they lost half their height, and bent into arcades, like Roman aqueducts. A long cornice was next formed on the top, and above it rose castles innumerable, all perfectly alike. These soon split into towers, which were shortly after lost in colonnades, then windows, and at last ended in pines cypresses, and other trees, even and similar. This is the fata morgana, which for twenty-six years I have thought a mere fable." To produce this pleasing deception, many circumstances must concur, which are not known to exist, at least to the same extent, in any other situation. The spectator must stand with his back to the east, in some elevated place behind the city, that he may command a view of the whole bay; beyond which the mountains of Messina rise like a wall, and darken the back-ground of the picture. The winds must be hushed, the surface quite smooth, and the tide at its height. All these events coinciding, as soon as the sun surmounts the eastern hills behind Reggio, and rises high enough to form an angle of forty-five degrees on the water before the city, every object existing or moving at Reggio will be repeated a thousand-fold, as if in a looking-glass composed of facets or planes inclined to each other. Each image will pass rapidly off in succession as the day advances, and the stream appears to carry down the face upon which it appeared. Thus the parts of this moving picture will vanish in the twinkling of an eye. Sometimes the air is at the same moment so loaded with vapours, and undisturbed by winds, as to reflect objects in a kind of aerial screen, rising about thirty feet above the level of the sea. In cloudy heavy weather they are drawn on the surface of the water, bordered with fine prismatic colours.

Father Antonio Menasi published an express treatise at Rome, in 1773, entitled "Dissertazione prima sopra un fenomeno vulgaremente detto Fata Morgana," of which a short abridgment is given in Nicholson's Journal, 4to. vol. i. p. 225, with a large engraving. This author does not appear to have philosophized successfully upon the appearances, which are, indeed, very far from having been at all explained. The reader who may wish to consider the facts, is referred to Huygens, "De Coronis et Parhelus;" Priestley's "Optics for Atmospheric Phenomena;" Huddart, in the Phil. Trans. 1797; Vince, in the same work for 1799; and Wollaston for 1800; which three last are in the journal last quoted. The fata morgana seems to depend upon the general principles of looming, which Wollaston has very successfully displayed, together with the reflection from particles of water floating in the air. These particles doubtless assume prismatic figures by coagulation; and it is, perhaps, a mistake, to suppose them to be spherical, even at their primary condensation, in the fluid state of minute floating particles.

FATHOM, a long measure, containing six feet, chiefly used at sea for measuring the length of cables and cordage.

FEATHER, in physiology, a general name for the covering of birds; it being common to all the animals of this class to have their whole body, or at least the greatest part of it, covered with feathers or plumage.

There are two sorts of feathers found on birds, *viz.* the strong and hard kind, called quills, found in the wings and tail; and the other plumage, or soft feathers, serving for the defence and ornament of the whole body. All birds, so far as yet known, moult the feathers of their whole body yearly.

The feathers of birds make a considerable article of commerce, particularly those of the ostrich, heron, swan, peacock, goose, and other poultry, for plumes, ornaments of the head, filling of beds, and writing pens. There are scarcely any birds but what bed-feathers may be procured from, particularly those of the domestic kind; yet swans, geese, and ducks, are those that furnish most, and the best. Geese are plucked three times a year, towards the end of May, about Midsummer, and at the latter end of August; but chiefly when the feathers are ripe, that is, when they are perceived to fall off of themselves. The feathers of dead birds are in the least esteem, upon account of the blood imbibed by the quill, which putrefying, communicates an offensive smell to the feather, and takes some time to evaporate; for which reason live birds should not be stripped till their feathers are ripe. They are imported in this country from Poland and Germany. They are divided in white, half grey, and grey, and valued accordingly. The best feathers should be white, downy, void of large stems, fresh, and sweet. Care should be taken that no sand be intermixed, which is frequently practised to increase the weight. Ostrish feathers are dyed and dressed by the feather-dressers, to serve as ornaments. They are a very costly article, brought to us from Africa, and particularly the coast of Barbary. See Down.

FEATHER *edged*, among carpenters, an appellation given to planks or boards, which have one side thicker than the other.

Feather, *prince's*, a plant, otherwise called amaranth. See Amaranthus.

FECES. The excrementitious matter of animals, evacuated per anum, consists of all that food which cannot be employed for purposes of nutrition, considerably altered, at least in part, and mixed or united with various bodies employed during digestion, to separate the useless part of the food from the nutritious. An accurate examination of these matters has long been wished for by physiologists, as likely to throw much new light on the process of digestion; but it must be admitted, that our knowledge on this subject is still very imperfect. Some of the older chemists have turned their attention to the excrements of animals; (Van Helmont's Custos Errans, sect. 6; Opera Helmont, p. 247; Neumann's Works, p. 585.) but no discovery of importance rewarded them for their disagreeable labour. Vauquelin has ascertained some curious facts respecting the excrementitious matter of fowls; and in the summer of 1806, a laborious set of experiments on human feces was published by Berzelius, undertaken, as he informs us, chiefly with a view to elucidate the function of digestion. (Gehlen's Jour. VI. 509.) About two years before, Thaer and Einhof had published a similar set of experiments on the excrements of cattle, made chiefly to discover, if possible, how they act so powerfully as manure. (Ibid III. 276.)

The human feces, according to the experiments of Berzelius, were found to contain

Water	73.3
Vegetable and animal remains	7.0
Bile	0.9
Albumen	0.9
Peculiar extractive matter .	2.7
Salts	1.2
Slimy matter, consisting of resin of bile, peculiar animal matter, and insoluble residue . . .	14.0
	100.0

To Vauquelin we are indebted for an analysis of the fixed parts of the excrements of fowls, and a comparison of them with the fixed parts of the food; from which some very curious consequences may be deduced.

He found that a hen devoured in ten days 11111.843 grains troy of oats; these contained

136.509 grains phosphate of lime
219.548 silica

356.057

During these ten days she laid four eggs, the shells of which contained 98.776 grains phosphate of lime, and 453.417 grains carbonate of lime; the excrements emitted during these ten days contained 175.529 grains of phosphate of lime,

58.494 grains of carbonate of lime, and 185.266 grains of silica; consequently, the fixed parts thrown out of the system, during these ten days, amounted to

	274.305	grains phosphate of lime
	511.911	carbonate of lime
	185.266	silica.
Given out	971.482	
Taken in	356.057	
Surplus	615.425	

consequently, the quantity of fixed matter given out of the system, in ten days, exceeded the quantity taken in by 615.425 grains.

The silica taken in amounted to	219.548 grains
That given out was only	185.266 grains
Remains	34.282

consequently, there disappeared 34.282 grains of silica.

The phosphate of lime taken in was	136.509 grains
That given out was	274.305 grains
	137.796

consequently, there must have been formed by digestion in the fowl, no less than 137.796 grains of phosphate of lime, besides 511.911 grains of carbonate; consequently, lime (and perhaps also phosphorus) is not a simple substance, but a compound, formed of ingredients which exist in oat-seed, water and air, the only substances to which the fowl had access; silica may enter into its composition, as part of the silica had disappeared; but if so, it must be combined with a great quantity of some other substance. (Ann. de Chim. xxix. 61.)

"These consequences," as Dr. Thompson observes, whom we follow in this article, "are too important to be admitted without a very rigorous examination. The experiments must be repeated frequently, and we must be absolutely certain that the hen has no access to any calcareous earth, and that she is not diminished in weight; because, in that case, some of the calcareous earth, of which part of the body is composed, may have been employed. This rigour is the more necessary, as it seems pretty evident, from experiments made long ago, that some birds, at least, cannot produce eggs, unless they have access to calcareous earth. Dr. Fordyce found, that if the canary bird was not supplied with lime at the time of her laying, she frequently died, from her eggs not coming forward properly. (On Digestion.) He divided a number of these birds, at the time of their laying eggs, into two parties: to the one he gave a piece of mortar, which the little animals swallowed greedily; they laid their eggs as usual, and all of them lived; whereas many of the other party, which were supplied with no lime, died.

Vauquelin also ascertained, according to Fourcroy, that pigeon's dung contained an acid of a peculiar nature, which increased when the matter is diluted with water; but gradually gives place to ammonia, which is at last exhaled in abundance. (Fourcroy, i. 70.)

FEE, in law, *feudum beneficium*, all land in England is in the nature of a feud or fee, and subject to the original conditions of the grant, which is supposed to come from the crown; but now that distinction is very immaterial.

FEE *simple*, is an estate to a man and his heirs, and is the largest estate which one can have; it descends to heirs of all kinds, and may be granted or devised at pleasure. When it is created by deed, it must be expressly stated to be to the grantee and his heirs; for an estate to A, for ever, is only good for life: in a will, however, this strictness is not required; any words which shew the intent of the testator will be sufficient. In a deed, a man cannot give a fee-simple to one, and then afterwards, in case he dies without heirs, to another. In a will, words which import this are often construed only to give the first taker an estate tail. It may be forfeited for treason or felony. Upon an exchange, a fee may pass without expressing the word heir; so also on a fine or recovery. A grant to the King, or a corporation, sole for ever, necessarily gives a fee, because they never die.

FEELERS, in natural history, a name used by some for the horns of insects, but is now used in familiar language instead of the word *Palpi*, 2, 4, or 6 articulated processes, placed in the mouth of insects, to assist in applying the food properly to the jaws. See ENTOMOLOGY.

FEELING, one of the five external senses, by which we obtain the ideas of solid, hard, soft, rough, hot, cold, wet,

dry, and other tangible qualities. This sense is the coarsest, but, at the same time, the surest of all others; it is besides the most universal. We see and hear with small portions of our bodies, but we feel with all. Nature has bestowed that general sensation wherever there are nerves, and they are every where, where there is life. Were it otherwise, the parts divested of it might be destroyed without our knowledge. It seems that upon this account, nature has provided that this sensation should not require a particular organization. The structure of the nervous papillæ is not absolutely necessary to it. The lips of a fresh wound, the periosteum, and the tendons, when uncovered, are extremely sensible without them. These nervous extremities serve only to the perfection of feeling, and to diversify sensation. Feeling is the basis of all other sensations.

FELAPTON, in logic, one of the six moods of the third figure of syllogisms, wherein the first proposition is an universal negative, the second an universal affirmative, and the third a particular negative.

FELIS, the *cat*, in natural history, a genus of Mammalia, of the order Feræ. Generic character: six foreteeth, intermediate ones equal, three grinders on each side; tongue prickly backwards; claws retractile. Animals of this comprehensive class never unite in companies for mutual defence, but accomplish their ferocious and bloody purposes with solitary energy. They are swift and strong, have many of them a peculiar facility in climbing trees, and falling from any considerable height, alight on their feet. They spring on their prey with the suddenness of lightning, and suck its blood before they devour it. They will eat vegetables only when other food is not within their reach. They are principally distinguished by their large and pointed claws, which are lodged in a sheath, and protruded or withdrawn at pleasure. The numerous species of this genus differ extremely in size and in colour, but in form and character possess a family resemblance, and are crafty, fierce, and sanguinary. There are twenty-three species, of which we shall notice those which follow.

F. leo, or the lion. This is the largest species of the Felis genus, and has occasionally been known to measure eight feet in length, exclusively of its tail, which is about three or four. Its colour is of a pale tawny, and the male possesses an extremely full and flowing mane. The female is destitute of this, and is considerably smaller than the male. It has been known to live, in a state of confinement, to the age of sixty-three or seventy years, though, from a philosophical examination of its general structure, it would be concluded that its average duration would not exceed twenty-five. The parental affection of the lioness is extreme: in support of her young she braves the most formidable dangers, and is wrought up to a pitch of agitation and exertion, which render her, in such circumstances, a more terrible adversary than the lion himself. She produces her young in the most remote and sequestered situations, and to provide for their wants, engages in the most rapid excursions, and most daring attacks, returning to her cubs with the fruit of her toils and dangers, with the most impatient impetuosity, and feeding them with the yet convulsed members of her prey. It is reported, by some authors, that she endeavours, occasionally, to obscure the track to her den, by brushing out the marks of it with her tail, and when suspicious of particular danger to her young, will remove them in her mouth to a place of greater security, with looks of unutterable menace and antipathy at any creature, however formidable, which may shew the slightest disposition to impede her progress. She produces but one litter, consisting of four or five in number, in the year. These are at first extremely small, little exceeding the size of a half grown kitten, and they are five years in attaining their full growth.

The lion is found in the warmer regions of Asia, but attains his highest perfection in the interior of Africa. His strength is such, that with a single stroke of his paw he has broken the back of a horse, and he has been known, not unfrequently, to carry off a young buffalo between his teeth. He rarely engages in full daylight in the pursuit of prey, but on the approach of night quits his habitation, and with a roar which can be resembled only to a peal of thunder, and overwhelms the other inhabitants of the wilderness or forest with consternation, commences his career of havock. His sense of smell is far from being acute, and he depends in the chase only upon actual sight or probable inference. He frequently consumes at one repast sufficient to satisfy him for two or three days; he breaks the bones of the buffalo with perfect ease, and frequently swallows them;

and the reversed prickles on his tongue are of extraordinary strength and extension. After a full repast, he returns to his den and enjoys a state of slumber and repose, till the calls of hunger rouse him to fresh activity, and impel him to recommence the work of blood. The lion, in the exertion of his full energies, must present one of the most impressive images that can be conceived. The general majesty of his countenance, surrounded by his full mane intensely erected, and lighted up by the glaring indignation of his eye, connected with the thunder of his voice, and all the apparatus of destruction in his mouth and paws, has, in every age, caused him to be considered as furnishing admirable materials for sublime and terrific imagery.

At the Cape of Good Hope, it is by no means uncommon to hunt the lion, and in an open and spacious plain, in which he finds it impossible to escape his pursuers by flight, he checks his progress, and fronts his adversaries, awaiting their attack. Several of the dogs which first dare to assault him generally fall under his stroke, but in a few moments he is overwhelmed by numbers, and literally torn to pieces. The negroes of the Cape are reported to eat his flesh; and his skin, which was formerly deemed a mantle for a hero, is now more frequently employed for the bed of a Hottentot.

It is imagined that lions are inexpressibly less numerous in Africa now than formerly, and it is stated by Shaw, that all Libya could at this time scarcely supply that number, which was sometimes exported to Rome even in a single year. In proportion as population has extended, and national intercourse has advanced, their range has necessarily become more limited, and their acquaintance with man seems to have considerably checked that daring, which was supposed by many incapable of being daunted. The lion's valour diminishes in proportion as he resides near the habitations of men, whose ingenuity and resources he seems well aware must always secure them a superiority in the conflict with other animals, and whose appearance therefore, he shuns as that of his most formidable adversary. In the neighbourhood of the small towns of Africa, even women and children have not unfrequently driven lions from their lurking places. When taken young, they can be taught to sustain confinement without difficulty, and will not only manifest tranquillity and contentment, but occasionally engage in sports and gambols with smaller animals, among which they have been led to associate. They are susceptible of attachment and gratitude, will caress their keepers, display a magnanimous forbearance with respect to the offensive freedom and petulant insults of weaker creatures, and after having once, as it were, pledged themselves for the security of any, which, by an act of wantonness, may have been thrown as victims into their den, will endure extreme hunger before they can permit themselves to destroy them. The natural excitability of these animals, however, is so great, that all the discipline of education is frequently insufficient effectually to repress their passions within secure limits, and in some unlucky coincidence of circumstances, those familiarities with them, which had been permitted without the slightest resistance or reluctance, have proved fatal to the persons who engaged in them. Though the lion frequently attacks his prey in open chase, he generally adopts the system of ambuscade, and will lurk on his belly in some thicket, frequently near the water, awaiting the approach of any animal which its evil destiny may impel near it, on which he will spring with a sudden bound, rarely failing of success, and sometimes reaching to the distance of twenty-feet. When this leap is unsuccessful, the object is permitted to escape without pursuit, and he retraces his steps slowly to the thicket, as it were abashed by his failure, and anticipating the consequences of greater adroitness in his ensuing effort.

Lions have in various countries been employed as emblems of state, and insignia of sovereignty. In Persia, two large lions with fetters of gold are stationed, on days of peculiar ceremony and splendour, on each side of the hall of audience; and in Rome, Anthony was drawn through the streets by lions harnessed to his chariot. To furnish entertainment for the inhabitants of that splendid and luxurious city, lions were conveyed in vast numbers from the interior of Africa, to exhibit at the public festivals, at which they fought with each other, with other animals, and even at length with men. This diversion was first exhibited by Quintus Scævola, but was afterwards carried to far greater extent. Sylla displayed in the Arena a hundred lions, during his pretorship. Julius Cæsar, to conciliate the people, entertained them with no fewer than four hundred: and Pompey imported, at vast expence, and with the most elaborate research, the immense number

of three hundred and fifteen males, and two hundred and seventy-five females. For the lion and lioness, and their whelps, see Mammalia, Plate XIII.

F. tigris, the tiger. This is called by Linnæus the most beautiful of quadrupeds, a character which would not be thought correctly applicable, were the judgment on this subject to be determined from the skins in a museum, or from a view of the animal itself, in that confined state in which it must ever appear in this country. But in its native region, and unchecked health and energies, it exhibits a bloom and radiance unequalled by any of the brute creation. Its ground colour is an intense orange colour, and defined stripes of pure black, in some parts double, and in others single, mark its body transversely, extending through the clear white of the sides. It is little inferor in size to the lion, and in some instances has been seen even larger than any lion mentioned by travellers, extending, from the nose to the end of the tail, to fifteen feet in length. Of all the carnivorous tribes, this species is considered as the most sanguinary and destructive. It appears to delight in the infliction of pain and the effusion of blood. After satisfying its hunger, it still continues to worry and destroy. If unmolested in the enjoyment of its prey, it will absolutely bathe its head in the blood and entrails of its victim, and while exhibiting this spectacle of horror, appear to enjoy that ecstacy, which arises necessarily from the gratification of the most impetuous and irresistible instincts. Though frequently confined, its ferocity is incapable of being subdued, and those sports, or freedoms, on the part of its keeper, which the lion admits with impunity, if not with satisfaction, would be fatal to the man who should dare practise them with the tiger. Tigers are found only in Asia, and attain their perfection of size and beauty, and their extreme degree of rapacity and fierceness in India, where they commit often the most dreadfnl havock, and lurking among thickets, and near villages, assault unwary travellers as well as the inferior animals; and in districts thinly peopled are the most dreadful terror and plague of the inhabitants. They seldom, if ever, engage in the violent and persevering chase of any animal, but practise, almost uniformly, the mode of ambush, rushing on their victim with almost unerring accuracy, and making those extensive bounds, which can result only from superlative elasticity and vigour.

The name tiger, in the language of the Armenians, signifies an arrow, and aptly expresses the agility of those movements, by which these animals seize upon their prey. The sounds which they utter in this moment of seizure are stated to be the most hideous and appalling that imagination can conceive. Animals of considerable size are not only attacked by a tiger without the slightest hesitation, but give no impediment from their bulk to his carrying them off to some thicket, where he may enjoy, in unmolested solitude, his feast of carnage. A man, or even a young buffalo, has been thus disposed of by him with great facility, and after sucking the blood of his victims with the most intense application, he proceeds to tear them in pieces and devour them. Conflicts are reported by travellers not unfrequently to occur between the lion and the tiger, carried on with all that intrepidity and perseverance, with all that energy and fierceness, which might naturally be expected, and ending sometimes only in the complete destruction or mutilation of both. At Siam it is not unusual for elephants to be baited by a tiger, constituting a similar display of savage power and skill with what is afforded in this country by a bull and dogs. Two elephants, well defended by artificial guards on their heads and great part of their trunks, are related, in one instance, to have been introduced to the arena, where was a tiger tethered by cords: one of the elephants approaching it while under this extreme disadvantage, struck it several heavy blows on its back, and laid it motionless on the ground; it was then untied, and soon afterwards, being considerably recovered, it bounded, with an immense spring and a most hideous roar, at the trunk of its antagonist, who parried the attempt with astonishing adroitness, and, receiving the tiger on his tusks, hurled it into the air. The other elephant was at this time unfairly allowed to join his companion, and each inflicted several severe blows on their common enemy, who must have perished indeed, under their united efforts, if the fight had not been terminated at this crisis by the governor's command.—The boldness and vigour of the tiger were sufficiently displayed, however, and considering the restraints under which he laboured, and his continued combat, notwithstanding the first and almost fatal discomfiture, were truly admirable.

It is recorded by Mr. Pennant, that, in the beginning of the last century as a British party in India were indulging themselves in rural recreation and festivity, totally unsuspicious of danger, an immense tiger was seen advancing towards them, and was so near as to be almost in the act to bound upon them. Dismay and consternation instantly pervaded every individual present but one, who was a lady, and who, a with promptness and self-possession probably never exceeded, furled a large umbrella in the face of the tiger, and thus most happily effected its retreat.

The catastrophe of Mr. Monro, in similar circumstances, was recorded by one of his companions, and may be not improperly noticed in this connection. In the year 1792, several British gentlemen, together with Mr. Monro, went to shoot deer on Sangar island, on the shores of which they observed innumerable traces of the feet of both these animals, not only of the deer, but of the tiger. They continued their sport, however, for a very considerable time; and after completing it, were sitting down for refreshment near a jungle, when a tiger, with a most horrible roar, darted from the jungle, and seizing on Mr. Monro, hurried back with him to the thicket, dragging him through the thickest bushes with amazing rapidity, and making every thing bend and yield to its prodigious strength. A tigress accompanied it in its progress. The tiger was fired at by the two remaining gentlemen, and was obliged to drop its prey; and in a few moments afterwards, their unfortunate friend was advancing towards them weltering in his blood. He had received, however, such deep wounds from the teeth and claws of the tiger, as precluded the possibility of recovery, and after twenty-four hours of agony, he expired. The scene was dreadful beyond all the expression of words. At the time of the assault, an immense fire of several whole trees was burning by the spot, and shortly after their departure from these fatal shores the gentlemen observed the tigress to make her re-appearance, in all the agitation of unbounded fierceness and disappointed vengeance. The tigress produces but one litter, consisting generally of five young in a year. In her defence of these, that fury, which, even in ordinary times, seems to mark her character, is wrought up to a paroxysm, in which she defies all danger, and exposes herself frequently to certain destruction. See Mammalia, Plate XIV. fig. 3.

F. pardus, the panther. It was for some time a question, whether the panther were not to be found in the new as well as in the old world; it is now, however, fully ascertained not to belong to America. It is found in Africa, from the coast of Barbary to the south of Guinea, in the last of which it is found in considerable numbers. Its length is about six feet and a half without the tail, which generally measures three; its colour is a bright tawny yellow, thickly studded along the upper part of its body, with circles of black spots containing a single spot in the centre. It is extremely ferocious, and its depredations in Africa resemble those of the tiger in Asia; though the panther, indeed, abstains, unless when urged by extreme hunger, from attack on man. Its mode of attack is always by surprise, and bursting from the thicket with an immense spring, or approaching with extreme silence and caution on its belly, it lights instantly upon its prey, and the moment of alarm is made by it, frequently, the moment of destruction. In China, where the skins of beautiful and brilliant quadrupeds are in high estimation, there is a variety of this species, the skin of which is sold for about six guineas. The number of panthers imported by the rich and ambitious among the Romans, to supply the popular sports of that city, is almost incredible; four hundred and ten were exibibited by Augustus within only a few days, and the immense demands which were made on Africa, for this purpose, tended at length to render them procurable, in the territory of Mauritania, only with very great labour and expence. In that country they are at present rare, comparatively with what they must have been before those vast exportations; but farther to the south they are extremely numerous. See Mammalia, Plate XIV. fig. 2.

F. leopardus, or the leopard. This animal is principally distinguished from the preceding by its less lively yellow colour, its inferior size, and the closer arrangement of the spots with which it is diversified. Its manners are similar to those of the panther, and both inhabit the same territories. Among the vast herds of Lower Guinea they commit the most destructive havoc; and when they are impelled by hunger, every creature is exposed to their attack. They are often

taken in pit-falls by the negroes, who highly value their flesh, which in appearance, is not a little like that of veal; their teeth are arranged in fanciful dispositions by the women of the country, and hung about their necks and arms, both as amulets and ornaments; and their skins are exported to various parts of Europe, where they are particularly admired, and are sold for corresponding prices. There is in India a variety of this species trained with great success to hunt the antelope and other beasts. It is conveyed in a small vehicle to the spot of its intended exertions, and chained and hooded till it is let down as near to the herd as is thought convenient; it then makes every effort to reach them unobserved, advancing with extreme vigilance and caution, and when it perceives itself in a proper situation, it rushes with a succession of amazing bounds, five or six in number, towards its destined object, and is almost uniformly successful in securing it. On failure it returns to its owner, and after a short interval recommences its efforts. See Mammalia, Plate XIV. fig. 1.

F. uncia, or the ounce, is about three feet and a half in length, and has a skin beautifully varied with single spots, or oval collections of them, on a light-grey ground-colour. It is a native of China, Persia, and Barbary. Its sense of smell is not extremely acute, but its eye possesses exquisite discernment, on which account it is disciplined to the chase with wonderful success; and so gentle are its manners, that it is taken to the hunt on the crupper of the horse, behind its owner. It is not remarkable for speed in running, or at least for a continuance of rapid exertion, and is, indeed, incapable of it; but it seizes its prey by a few rapid bounds, in which it displays astonishing nimbleness and dexterity. It frequently ascends trees, from which it may dart on any animals leisurely and fearlessly passing beneath.

F. onca, the jaguar, is the most formidable of all the animals found in the new continent, and abounds particularly in the Deserts of Guiana; in passing which the Indians, who have an extreme dread of this animal, always kindle fires to keep it at a distance. In some of its manners and habits, it strongly resembles the tiger. It sucks the blood previous to devouring the flesh of its prey, in pursuit of which it is very swift, and will ascend trees of the loftiest and smoothest kind with astonishing facility; its howl is terrific. The female is said to produce two young at a birth. Its ground colour is a light brownish-yellow, which is varied with streaks and open spots of black. It is rather larger than a wolf, but is said to find a formidable, and often fatal, antagonist in the ant-eater, which, on being attacked by the jaguar, throws itself on its back, and with its long claws fixes on his throat, and kills him by suffocation.

F. concolor, the brown tiger, puma or cougouar. The body is tawny, immaculate, thin and long, beneath whitish, been called the American lion. It is the largest of the American beasts prey, and is extremely fierce and ravenous. It inhabits in many parts from Canada to Florida, and is found also in Mexico and Brazil. In the warmer climates it possesses its greatest perfection in vigour and courage, and will frequently cross rapid torrents to seize cattle grazing in inclosures near the habitations of man. It has been known to attack a wolf. It is a formidable enemy to the moose-deer, and others of that tribe; and will often mount trees to watch the animals that pass beneath, selecting the victims of its rapacity, and quitting them only after having exhausted their last drop of blood. This fierce animal, strange as it may appear, if taken young, is trained to become as inoffensive nearly as the common cat, like which animal also it purs; and will permit, without rage or resentment, all the rough caresses and violent gambols of boys. When satiated with food, it conceals the remainder.

The fur is used in the dress of the Aborigines, and the flesh is much esteemed by them as an article of food.

F. discolor, or the black tiger, is considered by many only as a variety of the former species. It is exceedingly strong in its limbs, and attains the size of a heifer of a year old. It is found in Brazil and Guiana; and is rapacious and savage in its disposition; and fortunately, therefore, not abundant. It eats the buds of the Indian fig occasionally, but more frequently the eggs of turtles deposited on the shore. Lizards, fishes, and young alligators, are all made prey by it. It swims with great rapidity. In quest of the alligator it employs the stratagem of lying down on its belly at the edge of the water, and striking it with its paws; the noise and motion induce the alligator to lift its head above the surface, when the claw of the black tiger is instantly fixed in its eye, and drags it to the land.

F. pardalis, or ocelot, is about four times the size of a domestic cat, the shape

of which it extremely resembles, and is one of the most beautiful of all variegated quadrupeds. It is a native of South America, and particularly destructive, which may be, in a great degree, accounted for, from the circumstance of its seldom devouring the flesh of animals, rather thirsting, with insatiable avidity, for their blood. In the mountainous tracts of Mexico and Brazil these animals are abundant, hiding themselves amidst the foliage of trees, whence they spring upon their prey beneath. They are reported frequently to stretch themselves out motionless on the branches of trees, to induce the monkey to approach and examine them, which, with his usual curiosity, he is in such circumstances prompted to do; this curiosity, however, is only the instant prelude to his destruction. These animals are scarcely capable of being tamed, and in captivity display incessant restlessness and ferocity.

F. tigrina, or the Cayenne cat, resembles the wild cat in size, habit, and character; is most elegantly spotted with black on a tawny ground, and is frequently to be found in various parts of South America. It is extremely wild and untameable. The spotted species of this genus of animals have been often so imperfectly marked by travellers, that much remains to be done before a complete description of them can be obtained; and the remoteness of their haunts from human habitations, which can be approached only amidst dangers insuperable by all but extraordinary minds and constitutions, will, there is reason to presume, long preclude their correct definition and full detail.

F. catus, or the common cat. The numerous varieties of the domestic cat are supposed to have proceeded from a race native in the north of Europe and Asia. In the wild state, its tail is somewhat shorter than in the state of domestication; its head is more flat, and its limbs are more muscular and bony. The general colour of the wild cat is that of a pale yellowish-grey, with dusky stripes and variegations; there are, however, great varieties both of colour and size. Wild cats are found not only in Europe and Asia, but also in America, where they existed before its discovery by Columbus. In Great Britain they are found chiefly in the mountainous and woody districts of the Island; and, as being the most rapacious quadrupeds in the country, have been designated by Mr. Pennant as the British tigers. They range by night in quest of prey, and commit fatal depredations on kids, poultry, and lambs; they likewise devour hares, small birds, and various species of vermin. They breed and principally reside in trees; and are equally prolific with the domestic cat. In the neighbourhood of the former the latter will often quit his residence for a short time, and after associating during this interval with the wild cat, will return to its former mansion. These animals are frequently destroyed by means both of traps and guns; the latter of which mode, however, is attended with some danger, as, if only slightly wounded, they will, without hesitation, attack the assailant in their turn, and inflict no contemptible revenge. In the county of Cumberland one of these animals was killed, not many years since, which measured from its nose to the end of its tail upwards of five feet. The cat is generally imagined to see best in the dark; and so peculiar is the structure of its eye, that the pupil is capable of contraction and dilatation, in proportion to the degree of light affecting it. This circumstance gives it a most important advantage in exploring and seizing its prey. The character and manners of these animals, in their state of domestication, are so generally known as almost to preclude the necessity of at all noticing them. Their expressions, whether of pain, anger, or love, are piercing, clamorous, and extremely harsh and hideous to the human ear. On the utterance of the sounds of distress by a single individual, multitudes will often assemble, and appear to express their compassion by the most disgusting squalls and yellings. The result, however, frequently is, that the sufferer from disease or accident, from which the original call proceeded, is torn to pieces by its companions, who, not uncommonly, afterwards fall upon each other with the most savage fierceness, inflicting wounds and death without the least sensibility or discrimination. These sanguinary contests are uniformly carried on by night, and instances are related, on respectable authority, in which they have been conducted with the most destructive havoc. Cats are remarkably fond of certain perfumes, both vegetable or mineral; and on this account are often very injurious to a garden or green-house, destroying the plants to which they are so partial. Cold and wet are avoided by these creatures with particular care, and their habits are particularly neat and cleanly, their fur being preserved by them, until in extreme

age, from the slightest soil; and the most elegant and splendid furniture being in no danger from annoyance by them. The female is frequently obliged to conceal her young from the male, to preclude their being injured and even devoured by him; yet, in some instances, the female herself has been ascertained, in opposition to one of the most grand and prevailing instincts of nature, to eat them immediately on producing them; in general, however, the young are nursed with particular attention and affection, and the accommodation of the parent to the sportive propensities and varying gambols of the kitten constitutes to the humane, and even the philosophic mind, an interesting spectacle. With respect to human beings, even those which have long protected and befriended it, the cat appears little susceptible of kind attachment on the change of habitations, quitting the family with which it had always lived, and returning to apartments to which, indeed, it had been long used, but where it could recognize no human friend. In this respect its manners exhibit a most disadvantageous contrast to those of the dog, which are in the highest degree social, affectionate, and grateful. The cat, however, often lives in habits of friendly intercourse with various animals in a state of similar domestication with itself, and to which, in a state of nature, it feels an almost unconquerable hostility. A French lady, of some eminence, by persevering attention and discipline, at length succeeded in accomplishing the extraordinary exploit of habituating her dog and cat, her bird and mouse, to take their food from the same plate. Cats, though in general by no means profound sleepers, often, and particularly in the depth of winter, and on the approach of snow, can be roused from their sleep only with extreme difficulty; and will, on these occasions, exhale a fragrance similar to that of cloves. On rubbing the backs of these animals the electric spark is immediately felt, and the Leyden vial may, in frosty weather, be charged from this source, by means of a connecting wire and a glass-footed stool. Those who are pleased with contemplating the operations of animated surprise or curiosity, in any of the productions of nature, will be not a little entertained by the experiment of placing before a young cat, for the first time, a looking-glass; its delight at the figure thus exhibited is soon allayed by that impossibility of touching it, which it finds to all its attempts; it at length looks behind the glass, and with great suddenness and vivacity shifts its examination both forwards and backwards, till at last it appears to observe the correspendence between the reflections on the mirror and the movements of its own foot gliding in various directions over the surface, and seems to have developed the mystery originally so perplexing.

F. lynx, or the lynx, is remarkable for its ears being long and erect, and tufted at the end with long black hairs. The skin of the male is more spotted than that of the female. In America and the North of Europe these animals are to be found in great abundance. They subsist by hunting squirrels, ermines, weasels, and other vermin, which they will pursue to the very tops of extremely high trees. They conceal themselves often among the branches, and watch with minute observation the approach of hares, deer, and other animals, which they seize with astonishing agility, and after having drank their blood, reject their carcases almost entirely, devouring often, of a whole sheep, little more than the brain and liver. When attacked by a dog, this animal places itself on its back, and seizing the throat of its adversary, often actually suffocates it, or obliges it at least to retire from the conflict. The sight of the lynx is proverbially acute; its howling greatly resembles that of a wolf; in confinement it appears restless, malignant and untameable, almost constantly uttering a snarling scream. The fur of these animals is an important article of commerce. The farther north they are taken, the whiter and more valuable they are; and the winter furs are preferable to the summer ones. The length of a Russian lynx, from nose to tail, is four feet six inches. The lynx of the ancients appears to have been the creature of imagination. See Mammalia, Plate XIV. fig. 4.

From the lion to the common cat, through all the intermediate species of this abundant genus, a strong resemblance exists in form, internal structure, and habits; the shortness of the intestines, the sharpness and number of the teeth, the structure of the feet and claws, are the same in all; they all feed on flesh, which they rather tear than masticate; they eat with slowness, and during the repast growl almost perpetually, as if apprehensive of its being intercepted from them; they all seize upon their prey by crafty approach and stealthy stratagem, rather than by open and intrepid attack. These are the animals from which man

has most to apprehend, and which have hitherto, in every age, more or less, carried on hostilities against him. The power of some creatures is greater, but their tempers are less ferocious, and they exercise their strength, not in acts of aggression, but only in those of retaliation; and others, while they are inexpressibly more numerous, are, at the same time, destitute of any formidable powers of annoyance, and fly from the sight of man with the greatest rapidity and alarm. But between man and the feline tribe a contest for dominion is kept up over extensive regions of the globe, many of them highly ornamented and productive, and calculated to become the abodes of harmony and civilization.

FELLOWSHIP, or *Company*, in arithmetic, is when two or more join their stocks and trade together, dividing their gain or loss proportionably.

Fellowship is either with or without time. Questions without time, or in the single rule of fellowship, as it is frequently called, are wrought by the following proportion.

As the whole stock to the whole gain or loss, so is each man's particular stock to his particular share of gain or loss.

Suppose three partners, A, B, and C, make a joint stock in this manner: A, puts in 24*l.*; B, 32*l*,; and C, 30*l.*: in all 96*l.*; with which they trade, and gain 12*l.*; required each man's true share of that gain? The first operation for A's part of the gain will stand thus:

L.		*L.*		*L.*		*L.*		
96	:	12	::	24	:	3	=	A's gain.
96	:	12	::	32	:	4	=	B's gain.
96	:	12	::	40	:	4	=	C's gain.

Proof, 3*l.* + 4*l.* + 5*l.* + 12*l.* the whole gain.

That is, if the total of all their particular gains amounts to the whole gain, the work is true; if not, some mistake has been committed.

FELLOWSHIP *with time*, usually called the *Double Rule of Fellowship*, because every man's money is to be considered with relation to the time of its continuance in the joint stock. It is worked thus: multiply each man's stock by the respective time he puts it in for, and add all the products, the total of which must be your first number through all the statings; the gain or loss the second, as before, and each man's particular stock, multiplied by its time, the third.

Note, the times and sums, (if not so given) must be reduced into one denomination, *i. e.* all years, all months, all weeks, or all days, &c.

Ex. Three merchants, A, B, and C, enter into partnership thus: A puts into the stock 65*l.* for eight months; B puts in 78*l.* for twelve months; and C puts in 84*l.* for six months: with this joint stock they traffic, and gain 166*l.* 12*s.*: it is required to find each man's share of the gain proportionable to his stock and time of employing it.

	L.				
1. A's stock,	65	×	8 months, the time it was employed	=	520
2. B's stock,	78	×	12 months, the time it was employed	=	936
3. C's stock,	84	×	6 months, the time it was employed	=	504
			The sum of all those products is		1900

Then, the several proportions will stand thus:

1960 : 166,6 :: 520 : 44, 2	=	44	4	0	for A's share.
1960 · 166,6 :: 936 : 79,56	=	79	11	2¼	for B's share.
1960 : 166,6 :: 504 : 42,84	=	42	16	9½	for C's share.
The whole gain	= *L.*	166	12	0	

FELO *de se*, in law, one who is felon of himself, *i. e.* being of sound memory, and of the age of discretion, or 14 years, kills himself. All his chattels, real and personal, are forfeited to the crown, when it is found by the Coroner that he is *felo de se*; a will, therefore, made by him, is void as to his personal estate, but not as to his

land or real estate; nor is his wife barred of her dower. If a man and his wife are possessed of a term, and the man commit suicide, the term is forfeited, and the wife shall not have it by survivorship. The Coroner must find the fact upon an inquest, on view of the body, in order to vest the goods in the king.

This law is, in our opinion, hard and unjust: if a man is determined to commit suicide, human laws can have no hold upon him: and the cruelty of punishing the descendant for the act of the father is so generally acknowledged, that where the party has any thing to forfeit, it is either found lunacy, or the crown gives up the forfeiture upon petition. The further punishment of a *felo de se* is, to be buried in a highway, and a stake run through the body. This being never practised but upon the poor, is become merely an odious distinction. The law of the Romans seems more reasonable, which only forfeited the estate, where the party killed himself to avoid punishment for a crime.

FELONY, in the general acceptation of law, comprises every species of crime which occasions, at common law, the forfeiture of land or goods. The punishment of a person for felony, by our ancient books, is 1st, to lose his life; 2dly, to lose his blood, as to his ancestry, and so to have neither heir nor posterity; 3dly, to lose his goods; 4thly, to lose his lands; and the King shall have year, day, and waste, to the intent that his wife and children be cast out of the house, his house pulled down, and all that he had for his comfort and delight destroyed. A felony by statute, incidentally implies, that the offender shall be subject to the like attainder and forfeiture, &c., as is incident to a felon at common law. This is now the punishment in case of a capital felony only; but for some offences, benefit of clergy is allowed, when the offence is punished only with transportation, imprisonment, &c. which are called felonies with benefit of clergy; but the goods and estate of the felon are forfeited as in cases of capital felony.

FELT, in commerce, a sort of stuff, deriving all its consistence merely from being fulled, or wrought with lees and size, without either spinning or weaving. Felt is made either of wool alone, or of wool and hair.

FELTING, the method of working up hair or wool into a species of cloth, independently of either spinning or weaving. A hatter separates the hairs from each other by striking the wool with the string of his bow, causing them to spring up in the air, which fall on the table in every direction, which is covered by the workman with cloth, pressing it with his hands, and moving the hairs backwards and forwards in different directions. In this manner the hairs are brought against each other, and their points of contact considerably multiplied, and the agitation gives each hair a progressive motion towards the root, in consequence of which the hairs become twisted together. As the mass becomes compact, the pressure should be increased, in order to keep up the progressive motion and twisting of the hairs, which is then performed with greater difficulty. The hair intended for the manufacturing of hats is always cut off with a sharp instrument, and not pulled out by the roots, because the bulb of the hair, which would come out with it, in the latter case, would render the end which was fixed in the skin very obtuse, and nearly destroy its disposition to unite with the adjacent hairs. The hairs should not be straight like needles, for then there would be no compactness in the stuff. The fibres of wool having naturally a crooked form, that substance is well adapted to the operation of felting. The hair of beavers, rabbits, hares, &c. being straight, cannot be used in felting, till it has been prepared for the purpose.

FEMME *covert*, in law, a married woman; so called from being under the cover, protection and influence of her husband.

FEMME *sole*, in law, a single or unmarried woman.

FEMME *sole trader*, a married woman, who, by the custom of London, trades on her own account, independent of her husband; who, by the same custom, is answerable for her own debts, and may be made a bankrupt.

FEMININE, in grammar, one of the genders of nouns. As there are but two sexes, so in fact, there can be but two genders.

The feminine gender serves to intimate that the noun belongs to the female. In Latin, the feminine gender is most commonly distinguished by the article *hæc*, as it is in the Greek by the article ἡ. In the French, the article *la* commonly denotes this gender, but we have no such distinction by articles in the English language.

FEMINEUS, *flos*, a female flower. By

this name Linnæus denominates a flower which is furnished with the pistillum, or female organ of generation, but wants the stamina or male organ. Female flowers may be produced apart from the male, either on the same root, or on distinct plants. The birch and mulberry are examples of the first case; willow and poplar of the second. Male and female flowers separated on the same plant constitute the class Monoecia of Linnæus; separated on distinct roots, the class Dioecia.

FEN, a place overflowed with water, or abounding with bogs; the term is also applied to such boggy lands as are naturally disposed to produce coarse vegetables, from the retention of water. In many parts of the kingdom, since the introduction of a laudable spirit of improvement in agriculture, much valuable land has been redeemed both in England and Ireland from bogs and fens. There are, however, vast tracts of land of this kind still in different districts, in Lincolnshire, Lancashire, Cambridgeshire, and the West of England. In short, there are but few counties without them, which, by proper inclosing, draining, pairing and burning, and the growth of suitable crops, might be rendered highly valuable; but which at present afford little except reeds, sedge, or rushes and coarse grass.

FENCE, in country affairs, a hedge, wall, ditch, bank, or other inclosure, made around gardens, woods, corn-fields, &c. See Agriculture.

FENCING, is the manner of attacking an adversary with the sword, and defending the person from his thrusts. It is necessary in acquiring this difficult art to use foils, or small thin swords, which being blunted at the points, and bending readily, prevents accidental wounds. The gladiators, who were compelled to sacrifice their lives for the amusement of the Romans, received instructions in the use of the sword, in order to lengthen the diversion of their cruel masters, who were fearful that sudden rage might otherwise prompt an abrupt termination of the combat. Kennet says, "Before the combatants fell to it in earnest, they tried their skill against one another with more harmless weapons, as the rudes, and the spears without heads, the blunted swords, the foils, and such like." To this Cicero admirably alludes, "If in the mortal combats of the gladiators, where the victory is decided by arms, before they actually engage, there are several flourishes given, more for a shew of art than a design of hurting; how much more proper would this look in the contention of an orator."

Fencing was indispensable to almost all ranks of people, long after armies had ceased to use swords in the field of battle, through the absurd fashion of wearing side-arms; when men of turbulent dispositions might have immediate recourse to weapons, it became necessary for the peaceable citizen to learn the best mode of defence, that he might not perish for an offence which would end at present in altercation. During the long period this suppossed ornament of the person was worn, numerous masters brought the art of using it to great perfection: but the French appear to have excelled every other nation in fencing, which may be attributed in a great measure to the physical properties of their bodies. Their teachers and their imitators have, therefore, been loud in its praises, asserting that the art should be taught in every polite academy, that the figure may be formed into complete grace by the active movements of the limbs and body in every possible position.

The professors divide fencing into two parts, which they distinguish from each other, by terming the first simple, and the second compound; the first they perform instantaneously and actively on the same line, either on the offensive or defensive. The principle on which they act, in this instance, is to push or make passes in any direction, to strike the least guarded part of the adversary, at the same time endeavouring to parry his thrusts.

Compound fencing consists of every description of feint appeals, entangling of foils, slashing, half thrusts, &c. contrived to distract the attention of the enemy, and thus suddenly and unexpectedly to reach that spot, which he skilfully defends in simple fencing; but the utmost care must be used to push at the proper moment when parrying.

FEND, in the sea language, imports the same as defend: thus fending the boat, is saving it from being dashed to pieces against the rocks, shore, ship's sides. And hence,

FENDERS are pieces of old hawsers, cable-ropes, or billets of wood, hung over the ship's sides, to keep other ships from rubbing against and injuring her.

FENNEL. See Anethum.

FEODAL, or feudal, *system*. This system originated from an assumed right obtained by conquest. When the Roman empire began to decline, and that government became too feeble to support

its most distant possessions, the Celtic nations, taking advantage of the reduced state of their various military posts, marched in such numbers through the southern parts of Europe, that opposition was deemed vain, and these northern hordes of Lombards, Franks, Huns, Goths, and Vandals, conquered them without difficulty. Acting upon their previous policy, they immediately introduced the military practice they had adopted towards their enemies, which was the general confiscation of land to the use of the most powerful chiefs; those, for obvious motives, distributed portions to enterprising subordinates, and even to the common soldier who had earned laurels in their predatory wars. The grants thus made were conditional, and called feoda, feuds, fiefs, or fees, which words imply the receipt of a reward given for past, and to secure future services; it might, indeed, be considered an actual sale of the person for military purposes, and the bargain became void, by the land reverting to the first possessor, if the party refused to march, or fled from his chief in battle; but this, or similar dishonourable conduct, was further guarded against by an oath of fealty.

Viewing this system only in the light of a firm bond of union subsisting between barbarians, it must be admitted, that a better could not well be devised, as the chief held officers of trust to his interest, by combining it with their own, and the vassals of the latter had an equally just reason to rely on the fidelity of others, who held land under their fee. The necessity of preserving their conquests, rather than any generous principle towards each other, evidently dictated the feodal system, and it was rendered almost impossible by this means that insurrections of the conquered nations should succeed, or that foreign armies could have the least chance of success, when opposed to a prince at the head of his feudatories; hence the nations thus constituted became powerful in the aggregate, and every individual, oppressed by his lord, had a common claim for redress, from the lowest feudatory in gradation to the chief, otherwise the whole fabric must have fallen into ruin. Exclusive of the feodal grants, there were others, termed allodial, which, though not free from military service, were given upon more liberal principles than the former; by those all free men had a right to dispose of their territory. In order to secure the prompt assistance of this description of persons, they were invited by a sort of honourable liberty to defend the country in battle, which was denied to the slaves, who were compelled to follow what was then thought the inglorious arts of peace. These allodial proprietors composed a national militia, and had the privilege of possessing moveables and money, a circumstance which compelled them to take the field at the requisition of the sovereign, when the country was in danger; but they were exempt from interfering in the disputes of feudal lords; and this exemption operated at length in subverting all their advantages; being independent of either party, both the lords and their vassals viewed them with jealousy, and each presuming upon their inability to protect themselves, injured and insulted them, well knowing that, as they were scattered at remote distances throughout the country, and forbidden by law from committing hostilities, they had nothing to apprehend from their resentment. The folly and barbarity of this conduct can only be accounted for by the consummate ignorance and brutality of all classes of men, who, inured to rapine, injustice, and bloodshed, paid homage to power alone, rejecting the sacred claims of property, and despising all other merit besides that of courage; the necessary consequence was, that the prince courted the most valiant and powerful of his chiefs, and neglected the allodial proprietors in proportion, because he could derive no advantage from them; they in return became completely disgusted with their situation, and wearied by the neglect of the monarch, the destruction of their property without hope of redress, and continual insults, they finally determined to solicit common protection, by resigning their lands to those lords who would deign to return them as feodal tenures: such was the effect of this cruel system of plunder, which made fiefs universal.

The advocates for a state of society so constituted urge, with some degree of justice, that a feudal lord, surrounded by his vassals, resembled the father of a numerous family, each reciprocally benefitting the other; and this was certainly the fact in some particular cases, when the lord happened to be of a benevolent disposition, and dispensed his favours liberally; such a man deserved, and, perhaps, received, gratitude equivalent, and hence originated feodal incidents. The expectants of fiefs, before they were hereditary, and the heirs afterwards,

educated under his immediate inspection, were attached to him as if they had been his own offspring, and received their lands when of age, with a determination to defend his interest to the utmost of their ability, in return for his careful and paternal wardship, which they further demonstrated by a grateful present, on taking possession. The former was called the incident of wardship, and the latter the incident of relief.

There was also an incident of marriage, which was founded upon the same principle as that of reliefs; this operated to prevent alliances with the family or vassals of inimical chiefs, and induced the lord to find such persons for his wards as would promote his own future advantage.

The incident of aid is explained by the term; in this case all vassals were compelled to assist their lord, whether his misfortunes were caused by extravagance, or losses by war.

The incident of escheat has been already noticed, and took place upon the default of the vassal in his customary service.

It will be observed, that this system depended solely on high conceptions of honour; while the chief made it apparent that he gloried in the fidelity and happiness of his vassals, they felt equal pride in supporting his splendour, and in endeavouring to elevate his consequence beyond that of his neighbour; but when the lord ceased to value the lives and property of his vassals, and made both subservient to purposes of mere ambition and avarice, the feodal system began to tremble to its base; wardship, instead of being as before mutually advantageous, was then rendered the means of filling the coffers of the lord, and the ward was sometimes ransomed, to prevent worse consequences: the result is obvious; the vassals received their inheritance almost exhausted, and viewed the incidents as so many lawless exactions, by which they might be stripped of large sums in reliefs, married to whom the lord pleased, purchase the freedom of marrying, or lose his land if he did neither. The aid which had been given as a tribute of gratitude on the marriage of the eldest daughter of the chief; when his heir received the distinction of knighthood; or when the lord was made prisoner; was demanded as a tax on the most trivial pretences: nor were escheats confined to real causes of forfeiture; on the contrary, every venial offence, entirely out of contemplation in the original compact, was converted into a crime, and pronounced just reasons for seizure. In this wretched situation, disheartened by oppression, and unable to resist, without virtually resigning the whole of their property by that single act, the vassals shrunk from the firm attitude they had assumed in battle, when fighting by the side of a generous chief, into the inertness of slaves, who, burning with secret hatred, often committed military errors purposely, equally involving their sovereign's and their own safety; from this cause knight's service had its origin. See KNIGHT'S *service*.

FEOFFMENT, in law, may be defined to be the gift of any corporeal purditament to another. He that so gives or enfeoffs is called the feoffer; and the person enfeoffed is denominated the feoffee. But by the mere words of the deed the feoffment is by no means perfected. There remains a very material ceremony to be performed, called livery of seisin, without which the feoffee hath but a mere estate at will. Livery in deed is the actual tradition of the land, and is made either by the delivery of a branch of a tree, or a turf of the land, or some other thing, in the name of all the lands and tenements contained in the deed; and it may be made by words only, without the delivery of any thing; as if the feoffer, upon the land, or at the door of the house, says to the feoffee, "I am content that you should enjoy this land according to the deed." This is a good livery to pass the freehold. The livery within view, or the livery in law, is when the feoffer is not actually on the land, or in the house, but, being in sight of it, says to the feoffee, "I give you yonder house, or land; go and enter into the same, and take possession of it accordingly:" This livery in law cannot be given or received by an attorney, as livery in deed may; but only by the parties themselves. A feoffment cannot be made of a thing of which livery cannot be given, as of incorporeal inheritances, such as rent, advowson, common, &c.; though it be an advowson, &c. in gross. A man may either give or receive livery in deed by letter of attorney; for since a contract is no more than the consent of a man's mind to a thing, where that consent or concurrence appears, it were most unreasonable to oblige each person to be present at the execution of the contract, since it may as well be performed by any other

person, delegated for that purpose by the parties to the contract.

FERÆ, in natural history, an order of quadrupeds, of which the distinguishing characters are, fore-teeth conic, usually six in each jaw; tusks longer; grinders with conic projections; feet with claws; claws subulate; food, carcasses, and preying on other animals; this order comprehends the following genera:

Canis,	Phoca,
Didelphis,	Sorex,
Erinaceus,	Talpa,
Felis,	Viverra,
Mustela,	Ursus,

which see.

FERÆ *naturæ*. Animals feræ naturæ, of a wild nature, are those in which a man hath not an absolute, but only a qualified and limited property, which sometimes subsists, and at other times doth not subsist; and this qualified property is obtained either by the art and industry of man, or the importence of the animals themselves, or by special privilege, as in case of game.

A qualified property may subsist in animals *feræ naturæ* by the art and industry of man, either by his reclaiming and making them tame, or by so confining them, that they cannot escape and use their natural liberty; such as deer in a park, hares or conies in an enclosed warren, doves in a dove-house, pheasants or partridges in a mew, hawks that are fed and commanded by the owner, and fish in a private pond or in trunks. These are no longer the property of a man than while they continue in his keeping or actual possession; but if at any time they regain their natural liberty, his property instantly ceases; unless they have *animum revertendi*, which is only to be known by their usual custom of returning. Larceny cannot be committed of things *feræ naturæ* while at their natural liberty; but if they are made fit for food, and reduced to tameness, and known by the taker to be so, it may be larceny to take them. 1 Haw. 94. See Game.

FERGUSON (James,) an eminent experimental philosopher, mechanic, and astronomer, was born in Bamffshire, in Scotland, 1710, of very poor parents. At the very earliest age his extraordinary genius began to unfold itself. He first learned to read, by overhearing his father teach his elder brother; and he had made this acquisition before any one suspected it. He soon discovered a peculiar taste for mechanics, which first arose on seeing his father use a lever. He pursued this study a considerable length, while he was yet very young; and made a watch in wood-work, from having once seen one. As he had no instructor, nor any help from books, every thing he learned had all the merit of an original discovery; and such, with inexpressible joy, he believed it to be.

As soon as his age would permit, he went to service; in which he met with hardships, which rendered his constitution feeble through life. While he was servant to a farmer, (whose goodness he acknowledges, in the modest and humble account of himself which he prefixed to one of his publications) he contemplated and learned to know the stars, while he tended the sheep; and began the study of astronomy, by laying down, from his own observations only, a celestial globe. His kind master, observing these marks of his ingenuity, procured him the countenance and assistance of some neighbouring gentlemen. By their help and instructions he went on gaining farther knowledge, having by their means been taught arithmetic, with some algebra and practical geometry. He had got some notion of drawing, and being sent to Edinburgh, he there began to take portraits in miniature, at a small price; an employment by which he supported himself and family for several years, both in Scotland and England, while he was pursuing more serious studies. In London he first published some curious astronomical tables and calculations; and afterwards gave public lectures in experimental philosophy, both in London and most of the country towns in England, with the highest marks of general approbation. He was elected a Fellow of the Royal Society, and was excused the payment of the admission fee, and the usual annual contributions. He enjoyed from the King a pension of fifty pounds a year, besides other occasional presents, which he privately accepted and received from different quarters, till the time of his death; by which, and the fruits of his own labours, he left behind him a sum to the amount of about six thousand pounds, instead of which all his friends had always entertained an idea of his great poverty. He died in 1776, at 66 years of age, though he had the appearance of many more years.

Mr. Ferguson must be allowed to have been a very uncommon genius, especially in mechanical contrivances and executions; for he executed many machines himself in a very neat manner. He had

also a good taste in astronomy, and natural and experimental philosophy, and was possessed of a happy manner of explaining himself in an easy, clear, and familiar way. His general mathematical knowledge, however, was little or nothing. Of algebra he understood but scarcely more than the notation; and he has often told Dr. Hutton, he could never demonstrate one proposition in Euclid's Elements, his constant method being to satisfy himself as to the truth of any problem with a measurement by scale and compasses. He was a man of a very clear judgment in any thing he professed, and of unwearied application to study; benevolent, meek, and innocent in his manners as a child; humble, courteous, and communicative: instead of pedantry, philosophy seemed to produce in him only diffidence and urbanity.

The list of Mr. Ferguson's public works is as follows: 1. Astronomical Tables and Precepts for calculating the true times of new and full Moon, &c. 1763. 2. Tables and Tracts, relative to several Arts and Sciences, 1767. 3. An easy Introduction to Astronomy for young Ladies and Gentlemen, 2d edit. 1769. 4. Astronomy explained upon Sir Isaac Newton's principles, 5th edit. 1772. 5. Lectures on select subjects in Mechanics, Hydrostatics, Pneumatics, and Optics, 4th edit. 1772. 6. Select mechanical Exercises; with a short account of the Life of the Author, by himself, 1773. 7. The Art of Drawing in Perspective made easy, 1775. 8. An Introduction to Electricity, 1775. 9. Two Letters to the Rev. Mr. John Kennedy, 1775. 10. A third Letter to the Rev. Mr. John Kennedy, 1775.

FERMENTATION. The word fermentation, in general, is used to denote that change in the principles of organic bodies, which begins to take place spontaneously as soon as their vital functions have ceased, and by them are at length reduced to their first principles. This has been distinguished into three stages, the vinous or spirituous, the acid or acetous, and the putrid fermentation. It is ascertained almost beyond doubt, that the vinous fermentation takes place only in such bodies as contain saccharine juices. In this the most remarkable product is a volatile, colourless, slight inflammable fluid, which mixes with water in all proportions, and is called alcohol, which see. The acetous fermentation is distinguished by the product known by the name of vinegar, which is the least destructible of the vegetable acids. It does not appear, however, that fermentation is absolutely necessary for the production of this acid, as there are many other chemical processes by which it may be obtained or produced. In the putrid fermentation, bodies appear to be reduced into their most simple parts. Ammonia is the product which has been remarked as the chief of this process, and is no doubt produced by the combination of the hydrogen and nitrogen gases, which are disengaged together. See AMMONIA.

The acetous, like the vinous fermentation, is confined to vegetable substances; but the putrefactive process is most eminently perceived in animal bodies. These either putrefy immediately; or, if the putrefaction be preceded by either of the other stages, their duration is too short to be perceived. It is considered as an established fact, that the three stages of fermentation always follow in the same order in such bodies as are susceptible of them all; the vinous coming first, which is followed by the acetous and the putrefactive processes.

The spontaneous decomposition of bodies is retarded by extreme cold, by sudden drying of the parts or by preservation in closed vessels. The two first circumstances necessarily retard the chemical effects, by depriving the parts of that fluidity which is almost indispensably necessary in chemical processes. It will easily be understood that the third condition will retard the spontaneous decomposition of bodies, when it is considered that the atmosphere itself is the solvent, or at least the receptacle of many of the component parts of bodies with which it is disposed to unite. In well closed vessels the parts of organized bodies, which are disposed to fly off in the elastic state, are prevented from escaping; and such parts as might form new combinations, by absorbing either the contents or the component parts of the atmosphere, are prevented, for want of a free communication. The three conditions for the accomplishment of fermentation are, therefore, fluidity or moisture, moderate heat, or a due temperature, and the access of air; the fermentation will likewise be modified according to the various component parts of bodies.

In describing the vinous decomposition of vegetables, it will be of advantage to attend to that of mere sugar and water; the phenomena in these being more distinct, because less modified by foreign

admixture. If a considerable quantity of water, holding in solution about one third of its weight of sugar, be exposed to the air, at the temperature of about seventy degrees, after the addition of a small quantity of yeast, it soon undergoes a remarkable change. In the course of a few hours the fluid becomes turbid and frothy; oxygen is absorbed, bubbles of carbonic acid gas are disengaged, which rise to the surface and break. The disengagement becomes more and more abundant; mucilage is separated, part of which subsides to the bottom; and part being expanded into froth by the elastic fluid, forms yeast. During the course of several days, these effects gradually come to their height, and diminish again; after which they proceed very slowly, but are long before they entirely cease. The fermented liquor has then no longer the sweet taste it had before, but becomes brisk and lively, with a pungent, spirituous flavour. Its specific gravity is also considerably less than before; and when exposed to distillation it affords a light inflammable spirit. The quantity of this spirit, or alcohol, any fermented liquor will produce, is thought to follow some proportion of the change its specific gravity undergoes in fermentation; but the truth of this has not been clearly ascertained. Wine, cider, and beer, are well known liquors of this kind.

It is usual to put fermented liquors into casks before the vinous fermentation is completely ended; and in these closed vessels, the change goes on for many months. But if the fermentative process be suffered to proceed in open vessels, more especially if the temperature be raised to ninety degrees, the acetous fermentation comes on. In this a still greater portion of oxygen from the air is gradually absorbed; and this more especially as the surfaces of the liquor are oftener changed by lading it from one vessel to another. The usual method of doing this consists in exposing the fermented liquor to the air, in casks placed so that the sun may shine on them; which seems to be of advantage by raising the temperature of the liquor. By this absorption of oxygen the inflammable substance becomes converted into an acid. If the liquor be then exposed to distillation, vinegar comes over instead of alcohol or spirit.

When the spontaneous decomposition is suffered to proceed beyond the acetous process, the vinegar gradually becomes viscid and foul; a gas is emitted with an offensive smell; ammonia flies off, an earthy sediment is deposited, and the remaining liquid, if any, is mere water. This is the putrefactive process.

Though fermentation is much better understood at present, in consequence of modern researches into the nature of the gases, than it formerly was, it still remains an interesting object of research. It is not clearly ascertained what the yeast or fermented matter performs in this operation. It seems probable that the fermentative process in considerable masses would be carried on in succession from the surface downwards; and would perhaps be completed in one part of the fluid before it was perfectly begun in another part, if the yeast, which is already in a state of fermentation, did not occasion the process to begin in every part of the fluid at once. Experiments yet remain to be made towards ascertaining the arrangements and quantity of the component parts of alcohol. It appears that hydrogen in combination with carbon and water, in certain proportions, form this compound; that a greater proportion of oxygen converts it into vinegar; and that in the putrefactive process the hydrogen, carbon, and oxygen, are separated from each other, and fly off in the elastic state.

In the fermentation of wine, the tartar, which probably existed for the most part already formed in the juice of the grape, is separated, and exhibits the properties which are described in treating of that substance.

The fermentation of bread, by leaven, is thought to be of a different nature from the vinous fermentation. In this, the mucilage of the corn is not previously brought into the saccharine state. It quickly becomes sour, if the process be not stopped by baking; in which particular the fermentation seems to be of the acetous kind. The developement of carbonic acid divides the dough into thin parts, which are more effectually and better baked than they could have been in the solid consistent mass. When bread is fermented by means of yeast, the process seems to be of a saccharine or vinous nature. A very minute proportion of alum renders bread whiter, and its pores more small and numerous, but how it acts has not been ascertained. It does not seem, either from its quantity or quality, to be unwholesome.

FERN. See Filices. Fern is very common in dry and barren places. It is one of the worst of weeds for lands, and very hard to destroy, where it has any thing of a deep soil to root in. In some grounds the roots of it are found to the depth of eight feet. One of the most effectual ways to destroy it is often mowing the grass, and if the field be ploughed up, plentiful dunging thereof is very good; but a most certain remedy for it is urine. However, fern, cut while the sap is in it, and left to rot upon the ground, is a very great improver of land; for if burnt, when so cut, its ashes will yield double the quantity of alkali that any other vegetable can do.

In several places in the north, the inhabitants mow it green, and burning it to ashes, make those ashes up into balls with a little water, which they dry in the sun, and make use of them to wash their linen with, looking upon it to be nearly as good as soap for that purpose.

FERONIA, in botany, a genus of the Decandria Monogynia class and order. Calyx five-parted; petals five; berry globular, covered with a hard, rough, woody shell; one-celled; seeds numerous. There is but one species, *viz.* F. elephantum, elephant apple-tree, found in the East Indies. See Linn. Trans. vol. v.

FERRARIA, in botany, so named in honour of John Baptist Ferrarius, a genus of the Gynandria Trigynia class and order. Natural order of Ensatæ. Irides, Jussieu. Essential character: one-styled; spathes one-flowered; petals six, waved and curled; stigmas cowled; capsule three-celled, inferior. There are two species.

FERRET. See Mustela.

Ferrets, among glass-makers, the iron with which the workmen try the melted metal, to see if it be fit to work.

FERREOLA, in botany, a genus of the Dioecia Hexandria class and order. Essential character: calyx one-leafed, three-cleft; corolla one-petalled, three-cleft; male, filaments six, inserted into a semi-globose receptacle: female, germ oval; berry round, smooth, two-seeded. There is but one species; *viz.* F. buxifolia.

FERRUGINOUS, any thing partaking of iron, or that contains particles of that metal. See Iron. It is particularly applied to certain mineral springs, whose waters are impregnated with the particles of iron, generally termed chalybeates.

FERRY, in law, is a liberty by prescription, or the King's grant, to have a boat for passage upon a river, for carriage of horses and men for reasonable toll. Owner of a ferry, cannot suppress that ferry, and put up a bridge in its place, without a license. And if a ferry be granted at this day, he who accepts such grant is bound to keep a boat for the public good.

FERRULA, in botany, English *fennel-giant*, a genus of the Pentandria Digynia class and order. Natural order of Umbellatæ. Essential character: fruit oval, plane, compressed, with three streaks on each side. There are nine species.

FESSE, in heraldry, one of the nine honourable ordinaries; consisting of a line drawn directly across the shield, from side to side, and containing the third part of it, between the honour-point and the nombril. It represents a broad girdle or belt of honour, which knights at arms were anciently girded with.

Fesse *point* is the exact centre of the escutcheon.

Fesse *ways*, or *in* Fesse, denotes any thing borne after the manner of a fesse: that is, in a rank across the middle of the shield.

Fesse, *party per*, implies a parting across the middle of the shield, from side to side, through the fesse point.

FESTINO, in logic, the third mood of the second figure of syllogism, the first proposition whereof is an universal negative, the second a particular affirmative, and the third a particular negative: as in the following example:

FES No bad man can be happy:
TI Some rich men are bad men:
NO *Ergo*, some rich men are not happy.

FESTUCA, in botany, English *fescue grass*, a genus of the Triandria Digynia class and order. Natural order of Graminæ, or grasses. Essential character: calyx two-valved; spikelet oblong, roundish, with acuminate glumes. There are twenty-six species.

FEUDS. Estates in lands were originally at will, and then they were called *numera*; afterwards they were for life, and then they were called *beneficia*; and for that reason the livings of clergymen are so called at this day: afterwards they were made hereditary, when they were called *feoda*, and in our law fee-simple.

FEVER. See Medicine.

FEVERFEW. See MATRICARIA.

FEUILLEA, in botany, so called in honour of Louis Feuillee, a genus of the Dioecia Pentandria class and order. Natural order of Cucurbitaceæ. Essential character: male, calyx five-cleft; corolla five-cleft; stamens five; nectary five converging filaments: female, calyx five-cleft; styles three; pome hard, three-celled, corticose. There are two species.

FIBER, the beaver, in zoology, is made, by Linnæus, a species of castor. See CASTOR.

FIBRE, in anatomy, a perfectly simple body, or at least as simple as any thing in the human structure; being fine and slender like a thread, and serving to form other parts. Hence some fibres are hard, as the bony ones; and others soft, as those destined for the formation of all the other parts. See ANATOMY.

FIBRES, *flexible union of.* The strength of cordage and of other substances which are employed in the communication of motion, where flexibility is required, as well as the utility of other flexible materials, depends principally upon the lateral adhesion produced by twisting, or by the intermixture of fibres. The mechanism of simple spinning is easily understood; care is taken, where the hand is employed, to intermix the fibres sufficiently, and to engage their extremities as much as possible in the centre; for if any fibre were wholly external to the rest, it could not be retained in the yarn. See ROPE, SPINNING, &c.

FIBRIN. If a quantity of blood, newly drawn from an animal, be allowed to remain at rest for some time, a thick red clot, gradually forms in it, and subsides. Separate this clot from the rest of the blood, put it into a linen cloth, and wash it repeatedly in water till it ceases to give out any colour or taste to the liquid; the substance which remains after this process is denominated fibrin. It has been long known to physicians, under the name of the fibrous part of the blood; but has not till lately been accurately described. It may be procured also from the muscles of animals.

Fibrin is of a white colour, has no taste nor smell, and is not soluble in water nor in alcohol. It undergoes no change, though kept exposed to the action of the air; neither does it alter speedily, though kept covered with water. When exposed to heat, it contracts very suddenly, and moves like a bit of horn, exhaling at the same time the smell of burning feathers. In a stronger heat it melts. When exposed to destructive distillation, it yields water, carbonate of ammonia, a thick, heavy, fetid oil, traces of acetic acid, carbonic acid, and carburetted hydrogen gas. The charcoal, as Hatchett ascertained, is more copious than that left by gelatine or albumen. It is very difficult to incinerate, owing to the presence of phosphate of soda, and some phosphate of lime, which form a glassy coat on the surface. A considerable proportion of carbonate of lime also remains after the incineration of the charcoal.

Acids dissolve fibrin with considerable facility. Sulphuric acid gives it a deep brown colour; charcoal is precipitated, and acetic acid formed. Muriatic acid dissolves it, and forms with it a green-coloured jelly. The acetic, citric, oxalic, and tartaric acids also dissolve it by the assistance of heat; andt he solutions, when concentrated, assume the appearance of jelly. Alkalies precipitate the fibrin from acids in flakes, soluble in hot water, and resembling gelatine in its properties.

From the recent experiments of Fourcroy and Vauquelin on the muscular fibres of animals, there can be little doubt that fibrin, when treated with hot nitric acid, undergoes a suit of changes. 1. It is converted into a yellow matter, which still possesses the fibrous texture of fibrin, It has the property of converting vegetable blues to red, has a bitter taste, is but little soluble in water, and is insoluble in alcohol. It combines with alkalies, decomposes their carbonates, unites to oils, and gives them rancidity and acid properties. To this substance, Fourcroy and Vauqueline have given the name of yellow acid. 2. By the farther action of the nitric acid, this yellow matter becomes more soluble, acquires a reddish tinge, and seems to become soluble in alcohol. 3. The last state into which it is brought by nitric acid seems to be that species of bitter principle, which crystallizes and detonates when combined with ammonia.

The alkalies, when diluted, have but little effect upon fibrin; but when concentrated potash or soda is boiled upon it, a complete solution is obtained, of a deep brown colour, possessing the properties of soap. During the solution ammonia is disengaged. When the solution is saturated with muriatic acid, a precipitate is obtained similar to that from animal soap,

except that it sooner becomes hard and soapy when exposed to the air.

The earths, as far as is known, have little or no action on fibrin. Neither has the action of the metallic oxides and salts been examined. Fibrin is insoluble in alcohol, ether, and oils. The effect of other re-agents on it has not been examined.

FIBROLITE, a species of the topaz family, first observed by Bournon in the matrix of the imperfect corundum. Colour white, or dirty grey; hardness rather greater than that of quartz; specific gravity 3.214; texture fibrous, cross fracture compact; internal lustre glossy; infusible by the blow-pipe: usually in shapeless fragments. Bournon observed one specimen crystallized, in a rhomboidal prism, the angles of whose faces were 80° and 100°. It is composed, according to Chenevix, of 52.25 alumina, 38.00 silica, and 3.75 a trace of iron and loss.

FIBULA, in anatomy, a long bone placed on the outside of the leg, opposite to the external angle of the tibia. See ANATOMY.

FICTION *of law*, is allowed of in several cases: but it must be framed according to the rules of law; and there ought to be equity and possibility in every legal fiction. Fictions were invented to avoid inconvenience; and it is a maxim invariably observed, that no fiction shall extend to work an injury; its proper operation being to prevent a mischief, or remedy an inconvenience, that might result from the general rule of law.

FICUS, in botany, English *fig-tree*, a genus of the Polygamia Trioecia class and order. Natural order of Scabridæ. Urticæ, Jussieu. Essential character: receptacle common, turbinate, fleshy, converging, concealing the floscules, either on the same or a distinct individual: male calyx three-parted; corolla none; stamens three: female calyx five-parted; corolla none; pistil one; seed one. There are fifty-six species.

The fig is a striking instance of that contrivance which nature occasionally employs for the continuation of her species. We were for a long time unacquainted with the manner in which these plants were propagated: in other kinds it is the flower which contains the embryo of the fruit. In this, on the contrary, it is the fruit which encloses and conceals the flower. The mode in which the fig-trees are made to produce their fruit is called caprification. Among the several species of this genus which have been enumerated by botanists, the common fig is by far the most useful, and is cultivated in many parts of Europe for the excellence of its fruit. The wild as well as the cultivated kind is supposed to have been originally brought from Asia, from whence they have been spread over the southern parts of Europe, and are now to be met with in Languedoc, in Provence, in Spain, in Italy, &c. not to mention those of England, which are merely raised for the table, and not cultivated, like those abroad, for commercial purposes.

Where the climate is congenial to their nature, figs seem to thrive in almost any soil: but Duhamel observes, that they produce the most succulent fruit when growing among the rocks. They require a certain degree of heat: for although this gentleman saw figs of a monstrous size at Brest, yet they rarely became perfectly ripe, for want of the necessary warmth. The trees are generally raised from slips or layers, which readily strike root; and the manner which is often practised to effect this is simple enough, though rather singular. When it is proposed to propagate the plant by layers, a branch of the tree is made to pass through a tin funnel, or a wicker basket, filled with earth, into which the branch will soon shoot several fibres; it should then be cut asunder, below the basket, which should afterwards be placed in the earth. When it is desired to raise fig-trees that will bear fruit the next year, the finest branches of an old tree are laid in the earth, and one of a moderate size is caused to pass through a box, after being stripped of its bark for about a finger's breadth between two knots. The part so stripped is then placed about four fingers' breadth above the bottom of the box, and covered with earth. In due time the branch will shoot out several roots from the wounded part, after which it is separated from the stem by cutting it off below the box.

Several of the cultivated species, according to Duhamel, require only the ordinary attention paid to fruit-trees to make them ripen their fruit; but in the Archipelago, and in Malta, there are figs, both wild and domestic, that require a very singular mode of treatment to make them bring their fruit to perfection; the assistance we here allude to is named caprification, and is a phenomenon highly deserving our attention. Only two kinds of figs are cultivated in the Archipelago, the domestic and the wild; from the

former they gather that fruit which can only be brought to perfection by the assistance of the latter, or wild fig, which has been named caprificus, and in the country, ornos. This tree bears successively, in the same year, three sorts of fruit, to which the natives of the Archipelago have given different names. The first fruit, which they name fornites, are the autumnal figs; they appear in August, and fall in September and October. The second figs, called cratitires, are the winter figs, and remain on the trees from September till May; then come the third kind, or spring figs, known in the country by the name of orni. None of these fruits ripen, but they have a sleek even skin, of a deep green colour, and contain in their dry and mealy inside several male and female flowers, placed upon distinct footstalks, the former above the latter. In the first figs, or fornites, are bred small worms, which change to a species of cynips, peculiar to these trees. In October and November, these insects of themselves make a puncture into the second fruit, after which the autumnal figs fall; but the winter fruit, or cratitires, remain, as we have observed, till May, and enclose the eggs deposited by the gnats when they pricked them. In May, the third sort of fruit, called orni, begin to be produced by the wild fig-trees. This is much bigger than the other two; and when it grows to a certain size, and its bud begins to open, it is pricked in that part by the cynips of the winter figs, which are strong enough to go from one fruit to another to deposit their eggs. It sometimes happens that the insects of the cratitires are slow to come forth in certain parts, while the orni in those very parts are ready to receive them. In this case the husbandman is obliged to look for the cratitires in another part, and fix them at the ends of the branches of those fig-trees whose orni are fit to be pricked by the insects. If they miss the opportunity, the orni fall, and the insects from the winter figs fly away. None but those who are well acquainted with the culture know the critical moment of doing this; and in order to know it, their eye is perpetually fixed on the bud of the fig; for that part not only indicates the time that the insects are to issue forth, but also when the fig is to be successfully pricked: if the bud is too close, the fly cannot deposit its eggs; if, on the contrary, it is too open, the fruit falls to the ground. None of the wild figs are good to eat; their chief use is to assist in ripening the domestic kind, and the manner in which this is effected is as follows: during the months of June and July, the peasants take the orni at the time their insects are ready to break out, and carry them to the garden fig-trees; if they miss the proper time, the orni fall, and the fruit of the domestic fig will in consequence prove barren, and fall also. The natives are so well acquainted with these precious moments, that, every morning, in making their inspection, they only transfer to their garden fig-trees such orni as are well conditioned, otherwise they lose their crop. In this case, however, they have one remedy, which is to strew over the garden fig-trees another plant, in whose fruit there is also a species of insect, which, in some measure, answers the purpose. The countrymen so well understand how to manage their orni, that the flies which proceed from them ripen their domestic figs in the space of forty days.

FIDDLE. See VIOLIN.

FIELD, in heraldry, is the whole surface of the shield, or the continent, so called, because it containeth those achievements anciently acquired in the field of battle. It is the ground on which the colours, bearings, metals, furs, charges, &c. are represented. Among the modern heralds, field is less frequently used in blazoning than shield or escutcheon. See SHIELD, &c.

FIELD *book*, in surveying, that wherein the angles, stations, distances, &c. are set down. See SURVEYING.

FIELD *colours*, in war, are small flags of about a foot and a half square, which are carried along with the quarter-master general, for marking out the ground for the squadrons and battalions.

FIELD *fare*, in ornithology, the English name of the variegated turdus, with a hoary head. See TURDUS.

FIELD *pieces*, small cannons, from three to twelve pounders, carried along with an army in the field. See CANNON.

FIELD *staff*, a weapon carried by the gunners, about the length of a halbert, with a spear at the end; having on each side, ears screwed on, like the cock of a match lock, where the gunners screw in lighted matches, when they are upon command; and then the field-staffs are said to be armed.

FIELD *works*, in fortification, are those thrown up by an army in besieging a fortress, or by the besieged to defend the place. Such are the fortifications of camps, highways, &c.

FIFE, in music, is a sort of wind instrument, being a small pipe.

FIFTEENTH, an ancient tribute, or tax, laid upon cities, boroughs, &c. through all England, and so termed, because it amounted to a fifteenth part of what each city or town had been valued at; or it was a fifteenth of every man's personal estate, according to a reasonable valuation. In doomsday-book, there are certain rates mentioned for levying this tribute yearly; but since, any such tax cannot be levied but by parliament.

FIFTH, in music, one of the harmonical intervals or concords. The fifth is the second in order of the concords, the ratio of the chord that affords it is 3 : 2. It is called a fifth, as containing five terms or sounds between its extremes, and four degrees, so that in the natural scale of music it comes in the fifth place or order from the fundamental. The ancients called this fifth diapente. The imperfect and defective fifth, called by the ancients semi-diapente, is less than the fifth by a lesser semitone.

FIG, the fruit of the ficus, or fig-tree. See Ficus.

FIGURAL, or Figurate, *numbers*, are such as do or may represent some geometrical figure, in relation to which they are always considered as triangular numbers, pentagonal numbers, pyramidal numbers, &c.

FIGURATE *numbers*, are distinguished into orders, according to their place in the scale of their generation, being all produced one from another, *viz*. by adding continually the terms of any one, the successive sums are the terms of the next order, beginning from the first order, which is that of equal units 1, 1, 1, 1, &c.; then the 2d order consists of the successive sums of those of the first order, forming the arithmetical progression 1, 2, 3, 4, &c.; those of the 3d order the successive sums of those of the 2d, and are the triangular numbers 1, 3, 6, 10, 15, &c.; those of the 4th order are the successive sums of those of the 3d, and are the pyramidal numbers 1, 4, 10, 20, 35, &c.; and so on, as below.

Order.	Name.	Numbers.				
1.	Equals	1, 1,	1,	1,	1,	&c.
2.	Arithmetical	1, 2,	3,	4,	5,	&c.
3.	Triangulars	1, 3,	6,	10,	15,	&c.
4.	Pyramidals	1, 4,	10,	20,	35,	&c.
5.	2d Pyramidals	1, 5,	15,	35,	70,	&c.
6.	3d Pyramidals	1, 6,	21,	56,	126,	&c.
7.	4th Pyramidals	1, 7,	28,	84,	210,	&c.

The above are all considered as different sorts of triangular numbers, being formed from an arithmetical progression, whose common difference is 1. But if that common difference is 2, the successive sums will be the series of square numbers; if it be 3, the series will be pentagonal numbers, or pentagons; if it be 4, the series will be hexagonal numbers, or hexagons, and so on. Thus:

Arithmetical.	1st. Sums or Polygons.	2d. Sums, or 2d. Polygons.
1, 2, 3, 4,	Tri. 1, 3, 6, 10,	1, 4, 10, 20,
1, 3, 5, 7,	Sqrs. 1, 4, 9, 16,	1, 5, 14, 30,
1, 4, 7, 10,	Pent. 1, 5, 12, 22,	1, 6, 18, 40,
1, 5, 9, 13,	Hex. 1, 6, 15, 28,	1, 7, 22, 50, &c.

And the reason of the names triangles, squares, pentagons, hexagons, &c. is, that those numbers may be placed in the form of these regular figures or polygons. The figurate numbers of any order may be found without computing those of the preceding order, which is done by taking the successive products of as many of the terms of the arithmeticals 1, 2, 3, 4, 5, &c. in their natural order, as there are units in the number which denominates the order of figurates required, and dividing those products always by the first product: thus the triangular numbers are found by dividing the products 1×2; 2×3; 3×4, &c. each by the first product 1×2: the first pyramids by dividing the products $1\times2\times3$; $2\times3\times4$, &c. by the first $1\times2\times3$. And in general, the figurate numbers of any order n are found by substituting successively 1, 2, 3, 4, 5, &c. instead of z in this general expression $\frac{z \times z+1 \times z+2 \times z+3, \&c.}{1 \times 2 \times 3 \times 4, \&c.}$; where the factors in the numerator and denominator are supposed to be multiplied together, and to be continued till the number in each be less by 1 than that which expresses the order of the figurates required. See Simpson's Algebra.

FIGURE, in physics, expresses the sur-

face, or terminating extremities of any body; and, considered as a property of body affecting our senses, is defined a quality which may be perceived by two of the outward senses. Thus a table is known to be square by the sight, and by the touch.

Figures, in arithmetic, are certain characters, whereby we denote any number which may be expressed by any combination of the nine digits, &c. See Digit.

Figure, in botany, a property of natural bodies, from which marks and distinctive characters are frequently drawn. Figure is more constant than number; more variable than proportion and situation. The figure of the flower in the same species is more constant than that of the fruit: hence Linnæus advises to arrange under the same genus such plants as agree invariably in the flowers, that is, in the calyx, petals, and stamina, although the fruit or seed-vessel should be very different. The seed-vessels of the different species of French honey-suckle, wild senna, acacia, Syrian mallow, and sophora, are exceedingly diversified in point of figure. Hence some former botanists, who paid more attention to the parts of the fruit, considered many of these species as distinct genera, and denominated them accordingly. The figure of the seed-vessel is a very common specific difference in the Sexual Method.

Figure, in dancing, denotes the several steps which the dancer makes in order and cadence, considered as they mark certain figures on the floor.

Figure, in fortification, the plan of any fortified place, or the interior polygon, which, when the sides and angles are equal, is called a regular, and, when unequal, an irregular figure.

Figure, in geometry, the superficies included between one or more lines is denominated either rectilinear, curvilinear, or mixed, according as the extremities are bounded by right lines, curve lines, or both.

Figure, in grammar, a deviation from the natural rules of etymology, syntax, or prosody, either for brevity, elegance, or harmony.

Figure, in logic, denotes a certain order and disposition of the middle term in any syllogism.

Figure, in painting, and designing, denotes the lines and colours which form the representation of any animal, but more particularly of a human personage. Thus a painting is said to be full of figures, when there are abundance of representations of men; and a landscape is said to be without figures, when there is nothing but trees, plants, mountains, &c.

Figure, in rhetoric, is a manner of speaking different from the ordinary and plain way, and more emphatical; expressing a passion, or containing a beauty. See Rhetoric.

FILACER, or *filizer*, an officer of the Court of Common Pleas, so called, because he files those writs whereon he makes out process.

FILAGO, in botany, a genus of the Syngenesia Polygamia Necessaria class and order. Natural order of Compositæ Nucamentaceæ. Corymbyferæ, Jussieu. Essential character: calyx imbricate: female, florets among the scales of the calyx; down none: receptacle naked. There are seven species.

FILAMENT, in physiology and anatomy, denotes much the same as fibre. See Fibre.

Filament, in botany, the lower, slender, or thread-shaped part of the stamina, that serves as a foot-stalk for elevating the anthers, and connecting them with the vegetable. The term is equivalent to the stamen of Tournefort, and other botanists. With Linnæus, stamen is a geral term, the two parts of which are the filament or thread, and the anthera or summit. From the number of the filaments the first thirteen classes in the "Sexual Method" arise. With respect to figure, filaments are either slender, like a hair, as in plantain; flat, as in star of Bethlehem; wedge-shaped, as in meadow-rue; twisted like a screw, as in hirtella; awl-shaped, as in tulip; notched, as in many of the lip-flowers; or bent backwards, as in superb lily. The filaments in spider-wort and flower-of-a-day are beautifully covered with a fine hairy down. As to proportion, the filaments are either very long, as in plantain; very short, as in arrow-headed grass; of equal lengths, as in most flowers; or irregular and unequal, as in the lip and cross-shaped flowers, which, from this circumstance constitute the classes Didynamia and Tetradynamia, in Linnæus's Method. The situation of the filaments is generally opposite to the divisions of the calyx, and alternate with the petals.

Filaments, vegetable, form a substance of great use in the arts and manufactures, furnishing thread, cloth, cordage, &c. For these purposes the filamentous parts of hemp and flax are employed among us. Different vegetables have

been employed in different countries for the same uses. In some parts of Sweden a strong cloth is said to have been prepared from the stalks of hops. These have been tried here, but without success. Vegetable filaments, and the thread or cloth prepared from them, differ remarkably from wool, hair, silk, and other animal productions, particularly in their disposition to imbibe colouring matters; sundry liquors, which give a beautiful and durable dye to those of the animal, giving no stain at all to those of the vegetable kingdom. See DYEING.

FILARIA, in natural history, a genus of the Vermes Intestina class and order. Body cylindrical, filiform, equal, and quite smooth; mouth terminal, more or less perceptible, simple, with a roundish concave lip. There are about 18 species, divided into four sections: *viz.* A. infesting the mammalia; B. infesting birds; C. infesting insects in their perfect state; D. infesting the larvæ of insects. F. medinensis is found both in the East and West Indies, and is frequent in the morning dew, from which it enters the naked feet of the slaves, and creates the most troublesome itching, frequently accompanied with inflammation and fever. There is great difficulty in extracting it from its hold; the only method is, by cautiously drawing it out, by means of a piece of silk tied round its head; for if, by being too hasty, the animal should break, the part remaining under the skin grows with surprising vigour, and occasions an alarming, sometimes a fatal inflammation. It is frequently 12 feet long, and not larger than a horse-hair.

FILBERT, the fruit of the corylus, or hazel. See CORYLUS.

FILES, *manufactory of.* Many useful tools have been invented for performing mechanical operations, which consist of a number of wedges or teeth, which may be conceived to stand upon, or rise out of, a flat or curved metallic surface. When these teeth are formed upon the edge of a plate, the instrument is called a saw; but when they are formed upon a broad surface, it constitutes what is known by the name of a file. The comb-makers and others use a tool of this description, called a quonet, having coarse single teeth, to the number of about seven or eight in an inch. Fine tools of the same kind, namely, with single teeth, are called floats. When the teeth are crossed, they are called files; and when, instead of the notches standing in a right line, a number of single individual teeth are raised all over the surface, it is called a rasp. As the art of making files is nearly the same in its practice with regard to all the great variety of forms in which they are made, we shall confine our description to that of the flat file.

Very little need be said in explanation of the method of forging these articles. They are usually made of steel, or more rarely of iron, case hardened. The forged files are brought to a flat surface on the grindstone, and are then ready for the file-cutter. This artist is provided with a great number of chissels, consisting each of a piece of steel of moderate thickness, having a straight edge of greater length than the height of the chissel, the back of which terminates in a blunt angle or point in the middle of its length, upon which the blows are struck with a hammer of about five or six pounds weight, for middling sized files, having its head all on one side of the stem, so as to resemble the capital letter L, in order that it may by its own weight naturally dispose itself with the face downwards. The file is placed upon a plate of lead on a small low anvil, close to which the workman sits, and on the left side of the block of the anvil are fastened the two ends of a leather strap, which he brings over the file, and by putting his right foot into the loop holds it steadily in its place. In this situation, taking the chissel between his left finger and thumb, he applies its edge across the file, where the cuts are to begin at the point, and gives it a blow; the direction of the cut being inclined towards the tang, or that end of the file which is to go into the handle. Immediately after this commencing operation, he lifts the chisel, places its edge behind the other cut, and slides it forward till he feels it bear against the bur or protuberancy of the former cut, at which instant he gives the second blow; a third is repeated in like manner, and by a continuance of the same proceeding, the whole surface at length becomes covered with single strokes or notches, each of which presents an elevated sharp edge. The distance between stroke and stroke, or, which is the same thing, the coarseness of the file, depends entirely upon the violence of the blow, by which the bur is raised to a greater or less height; but it is not difficult with so weighty a hammer, after a very little practice, to give the strokes with great uniformity of impulse, and to repeat them with such frequency, as to perform this apparently delicate work with great speed and

precision. The coarsest files have about ten or twelve cuts in the inch of length, and the very finest have upwards of two hundred.

As soon as the whole surface of the file has been thus cut, the workman files the bur off with a smooth file, so as to leave very little more of the stroke than what has entered below the original surface; and then proceeds to give the second or cross-cut, forming an angle of about sixty degrees with the finest range of strokes. The intention to be answered by filing off the first edges is, to afford a more even surface for cutting the second, which is done exactly in the same manner as the first range, and likewise to give a suitable figure to the small teeth or lozenge-shaped prominences, which stand up upon the face of the file after the cutting is completed. If this filing off were to be omitted, the teeth would be pointed and irregular; whereas the useful and durable figure is that of a small rounded chisel or gouge.

It may be remarked, upon examining a file, that the first cut is always made more slantwise than the second. If this were not done, the small teeth would all lie behind one another, in rows in the direction of the length of the file, which would make corresponding grooves in the face of any piece of work that might be to be filed, instead of leaving the workman at liberty to vary his strokes, as is necessary when a flat surface is to be produced.

When the file is cut and finished on both sides, and on one or both edges, as may be required, it is ready for hardening, which is a chemical operation of some skill and ingenuity. The heat is given in a furnace, where the work can be regularly disposed, and for fine work a muffle is used. The file is first exposed to a low degree of ignition, which burns off any greasy or other matter that might adhere to its surface. It is then dipped, cold, in the grounds or thick sediment of beer, and while wet, into a powder made of burned or parched horn, or leather, or other coally animal matter, and of common salt, and in this state speedily dried by exposure to heat. Any other mucilage, which could be afforded at a moderate price, would probably answer the same purpose as the beer grounds. The file being then put into the ignited muffle, smokes, and soon becomes red hot, being not only defended from oxydation, by the covering of fused salt and animal coal which envelopes it on all sides, but being even rendered more steely upon its surface by the absorption of carbon. As soon as it has acquired the low red heat called cherry-red, it is taken out and plunged into pure cold water, which instantly cools it, and renders it very hard.

There are several variations adopted in the hardening process by different workmen, by means of which they differ in their success. Some file-makers, as well as gunsmiths and locksmiths, produce the intended effect so completely, that the whole surface of their work has a beautiful dull-grey aspect, every where alike; whereas other operators produce coally spots, which are obliged to be cleaned off. The files, when quite dry and clean, are slightly oiled, and kept in oiled paper.

The simple operation of file-cutting seems to be of such easy performance, that it is not at all to be wondered at, that machines for this purpose should have been very early invented. Mathurin Jousse, in "La Fidelle Overture de l'Art de Serrurier," published at La Fleche, in Anjou, in 1627, gives a drawing and description of one, in which the file is drawn along by shifts by wheel-work, and the blow is given by a hammer, which is tripped by the machinery. There are several in the "Machines Approuvées par l'Academie Royale de Paris;" and one in the "American Transactions;" and a patent was granted a few years ago, for improvements in the art, to the editor of this work.

The principal requisites in a machine for file-cutting are, that the file should be steadily supported, and the chisel adapted to the face, without any unequal bearing. Files are, however, for the most part, cut by hand; and the chief reasons are, 1. The cut by hand is, from its very nature, exactly of the depth the bur demands; whereas, in a machine, if the stroke be not nicely adapted to the shift, the file may be either shallow cut, or its bur may be thrown too close by an over heavy stroke; and 2. In machine cut files, there must always be a piece left at the beginning, at each corner, which requires to be cut off before hardening. This may be remedied in the machinery, but it has not yet been done.

FILICES, *ferns*, one of the seven families or natural tribes into which the whole vegetable kingdom is divided by Linnæus, in his "Philosophia Botanica." They are defined to be plants which bear their flower and fruit on the back of the leaf or stalk, which, in this class of im-

perfect plants, are the same. In the Sexual System, the ferns constitute the first order, or secondary division of the twenty-fourth class, Cryptogamia; in Tournefort's Method, they are the sixteenth class; and in Ray's the fourth, under the name of Capillares. Haller denominates them Epiphyllospermæ, that is, plants that bear their seeds on the back of the leaf: others term them Acaules, because they have properly no stem. These plants in figure approach the more perfect vegetables, being furnished, like them, with roots and leaves. The roots creep and extend themselves horizontally under the earth, throwing out a number of very slender fibres on all sides. The stem in these plants is not to be distinguished from the common foot-stalk, or rather middle rib of the leaves; so that, in strict propriety, the greater number of ferns may be said to be Acaules, that is, to want the stem altogether: in plants of the second section, however, the middle rib, or stalk proceeding from the root, overtops the leaves, and forms a stem, upon which the flowers are supported. The leaves proceed either singly, or in greater numbers, from the extremities of the branches of the main root. They are winged, or hand-shaped, in all the genera, except in adder's-tongue, pepper-grass, and some species of spleenwort. The flowers of the ferns, whatever be their nature, are in the greater number of genera fastened, and as it were glued to the back of the leaves; in some they are supported upon a stem or stalk, which rises above the leaves, and is either, as we said above, a prolongation of their middle rib, or issues out of the centre of the plant, unconnected with the leaves altogether. From these different modes of flowering arise the two sections, or divisions, of this natural order, *viz.* 1. those in which the parts of fructification grow upon the leaves; 2. those in which the flowers are borne upon foot-stalks that overtop the leaves.

FILLAGREE *work*, a kind of enrichment on gold or silver, wrought delicately, in manner of little threads or grains, or both intermixed. In Sumatra, manufactures of this kind are carried on to very great perfection. But what renders this a matter of great curiosity is, that the tools made use of are very coarse and clumsy. The gold is melted in a crucible of their own forming, and, instead of bellows, they blow with their mouths through a piece of bamboo. They draw and flatten the wire in a manner similar to that adopted by Europeans. It is then twisted, and thus a flower, or the shape of a flower, is formed. Patterns of the flowers or foliage are prepared on paper, of the size of the gold plate on which the fillagree is to be laid. According to this they begin to dispose on the plate the larger compartments of the foliage, for which they use plain flat wire, of a larger size, and fill them up with the leaves. A gelatinous substance is used to fix the work, and after the leaves have been placed in order, and stuck on, bit by bit, a solder is prepared of gold filings and borax, moistened with water, which they strew over the plate, and then putting it in the fire a short time, the whole becomes united. When the fillagree is finished, it is cleansed with a solution of salt and alum in water. The Chinese make most of their fillagree of silver, which looks very elegant; but is deficient in the extraordinary delicacy of Malay work.

FILLET, in heraldry, a kind of orle or bordure, containing only a third or fourth part of the breadth of the common bordure. It is supposed to be withdrawn inwards, and is of a different colour from the field. It runs quite round, near the edge, as a lace over a cloak. It is also used for an ordinary, drawn like a bar, from the sinister point of the chief, across the shield, in manner of a scarf; though it sometimes is also seen in the situation of a bend, fesse, cross, &c.

FILM, a thin skin or pellicle. In plants it is used for that thin, woody skin, which separates the seeds in the pods, and keeps them apart.

FILTER, in chemistry, a strainer commonly made of bibulous or filtering paper in the form of a funnel, through which any fluid is passed, in order to separate the gross particles from it, and render it limpid. There are several filters made of flannel and linen cloth. The filter produces the same effect, with regard to liquids, that the sieve does in dry matters. Filters are of two sorts: the first are simple pieces of paper or cloth, through which the liquor is passed without farther trouble; the second are twisted up like a skein or wick, and first wetted, and then squeezed as dry as possible; one end is put into the liquor to be filtrated, the other end is to hang out below the surface of the liquor; by this means the

purest part of the liquor distils drop by drop out of the vessel, leaving the dregs behind: a filter of this kind acts upon the principle of the syphon. Water is freed from various impurities by means of basins made of porous stone; this is often very necessary at sea, when the water becomes foul, and on land, where there are no fresh springs. The filter is of use to all those in and near the metropolis, who are supplied with water from the Thames, the New River, and the ponds from Hampstead. Many patents have been obtained for filtering machines, which may be seen in various parts of London.

We shall observe, that Mr. Peacock obtained, about twelve years since, one for a new species of filtration, by means of gravel of different sizes, suitable to the several strata. The various sizes of the particles of gravel, as placed in layers, should be nearly in the quadruple ratio of their surfaces; that is, upon the first layer, a second isto be placed, the diameters of whose particles are not to be less than one half of the first, and so on in this proportion. This arrangement of filtering particles will gradually fine the water, by the grosser particles being quite intercepted in their partly ascending with the water. An advantage in these filters is, that they may be readily cleansed by drawing out the body of the fluid, by which it will descend in the filter, and carry with it all the foul and extraneous substances.

A patent was also granted to Mr. Joshua Collier of Southwark, for a most ingenious method of filtering and sweetening water, oil, and every other liquid. The following is the contrivance, which combines the application of machinery with the antiseptic properties of charcoal. Fish oil is one of the liquids which he had particularly in view, to free it from every thing disagreeable, either in taste, smell, or colour; to accomplish which he poured a quantity of oil into a convenient vessel, heated to the temperature of 120° of Fahrenheit's thermometer, adding caustic mineral alkali of the specific gravity of 1.25. He then agitated the mixture, afterwards allowing it to stand till the sediment subsided, and then drew it off into another vessel, with a sufficient quantity of burnt charcoal finely powdered, and a small quantity of diluted sulphuric acid, to decompose the saponaceous matter still suspended in the oil, when the oil became clear at the surface: he then agitated the contents of this vessel, and left the coally, saline, and aqueous particles to subside; afterwards passing it through proper strainers, when it became quite transparent and fit for use.

The principle of the improved filtering machines consists in combining hydrostatic pressure with the mode of filtering *per ascensum*, which procures the peculiar advantage of causing the fluid and its sediment to take opposite directions. The filtering surface remains the same, while the dimensions of the chamber in which the sediment is received may be varied. To adapt the machines to every purpose for which they are intended, chambers must be provided, of various capacities, for the precipitated matter. The space required is very great with respect to the oil trade, and as all dimensions will be required occasionally, no particular limits can be fixed. For distilleries and breweries they may be smaller in proportion, and a very small chamber will be sufficient for domestic economy. If water is to be freed from noxious particles, it must be made to pass through an iron box in its way to the filtering chamber, and the box must contain charcoal finely powdered; the water is received into this box, and delivered by two apertures, which are opened and closed by cocks. Another part of the invention consists in filtering machines in the form of stills, in which charcoal may be repeatedly burnt, after any fluid substances have passed through it, for the purpose of freeing them from noxious particles, or discharging their colouring matter.

To the filtering apparatus of Mr. Collier, instruments are attached for discovering the comparative qualities of oils, which depend, in some measure, on their specific gravities: spermaceti oil, when compared with fish oils, being as 875 to 920. To do this a glass vessel, of any shape most convenient, is employed, with a glass bubble and a thermometer. If the oil is pure, the bubble sinks, when the mercury rises to a particular standard. When spermaceti oil is impure, the bubble floats, though of the temperature required. To determine the tendency of oils, used for burning, to congeal in cold weather, a freezing mixture may be put into a phial of thin glass, into which let a thermometer be immersed, and a single drop of the oil permitted to fall on the outside of the vessel, where it will instantly congeal. As the cold produced by the mixture decreases, let the temperature be observed,

by the thermometer, at which the oil becomes fluid, and runs down the side of the glass.

FIN, in natural history, a well known part of fishes, consisting of a membrane supported by rays, or little bony or cartilaginous ossicles.

The number, situation, and figure of fins, are different in different fishes. As to number, they are found from one to ten, or more; with respect to situation, they are *dorsal*, placed on the back; *pectoral*, generally situated on the side near the gills; *ventral*, on the belly before the vent; *anal*, when behind the vent; and *caudal*, terminating the tail; and as to figure, they are either of a triangular, roundish, or oblong square form. Add to this, that in some they are very small; whereas in others they are almost equal to the whole body in length.

FINAL *letters*, among Hebrew grammarians, five letters so called, because they have a different figure at the end of words from what they have in any other situation. These are caph, mem, nun, phe, tzade, all comprehended in the word *camnephatz;* which, at the end of words, are written thus, ךםןףץ; whereas, in any other situation their form is thus, כמנפצ, on which account they are likewise called biform.

FINANCES, in political economy, denote the revenue of a king or state.

In former times, when the whole revenue drawn from the people, by a few taxes, was considered as the personal property of the sovereign, the purposes to which it was applied depended on his discretion, or that of his minister. As few princes were inclined, in times of peace, to provide for the extraordinary charges of a state of warfare, these were defrayed by extraordinary contributions from the people, which ceased with the occasion. Few sovereigns possessed sufficient credit, either with their own subjects or foreigners, to contract debts, so that, at the conclusion of a war, there was no occasion for a greater expenditure than before its commencement, and the revenue drawn from the people reverted to its former state. It is the system of defraying extraordinary expenses by borrowing the money, for which an annual interest must be paid, and of suffering the debts thus incurred to accumulate, by which the sum to be annually paid is continually increasing, and the expenses of every war are rendered far greater than those which preceded it, that has swelled the revenue and expenditure of most of the nations of Europe to an enormous magnitude, and caused their systems of finance to become complicated and oppressive.

In Great Britain, where the system of running in debt, or, as it is commonly termed, the funding system, has been carried to a greater height than in any other country, its natural attendants, enormous taxation and expenditure, have made equal progress; and it is probably owing chiefly to the publicity which is given to all matters of finance, so that every person, with little trouble, may know how all the money raised for the public service is expended, that the people have been induced to submit to taxes, which both from their nature and amount would have appeared incredible to their forefathers.

The English system of finance rests on the produce of the various taxes which have been imposed at different periods, the aggregate amount of which, after deducting the expenses of collection, together with a few small articles, which cannot properly be called taxes, forms the whole of the public income: this income is annually appropriated to the several branches of the national expenditure, and when, in consequence of any extraordinary expenses, it is known that the income of the current year will be insufficient to meet all the demands upon it, it is usual to borrow the sum necessary to make up the deficiency, either from individuals or public bodies, and to allow a fixed rate of interest on the money thus obtained, till the principal shall be repaid, or till the period originally agreed upon shall have expired.

FINE, in law, is sometimes called a feoffment of record; or, rather, it is an acknowledgment of a feoffment on record: it has at least the effect of a feoffment in conveying lands, though it is one of those conveyances at the common law, by which lands and freeholds will pass without livery or seisin. It is an amicable composition of a suit, either actual or fictitious, by leave of the King's justices, whereby the lands in question become, or are acknowledged to be, the right of one of the parties. It is now a very general mode of conveyance, by reason of its extensive and binding effect. There are four sorts of fines, but that most usually employed is called, *fine sur conusance du droit come ceo qu'il a de son done*, or a fine upon acknowledgment of the right of the cognizee, as that which he hath of the gift of the cog-

nizor. The purposes for which fines are now levied are, to cut off estates tail, to bar the wife of her dower, and also to make purchasers more secure in their title; for by virtue of the statute 4 Henry VII. c. 24, all persons not within age, and not under disability, such as femmes coverts, persons insane, and beyond sea, are barred of their rights by a fine levied of lands, with proclamation, unless they claim within five years. The legal learning, with respect to the effect and operation and mode of levying fines, is so abstruse, that, in a general dictionary, it is better to consider them only, as in fact they are, a species of solemn conveyance for the barring the wife of dower when levied by her, which she is enabled to do notwithstanding coverture, or to cut off entails, &c. than to attempt an imperfect description of fines in particular.

FINERY, in the iron works, one of the forges at which the iron is hammered and fashioned into what they call a bloom or square bar. See Iron.

FINESSE, a French term, current in this country, and is used chiefly to denote that subtility made use of for the purposes of deception.

FINGER *board*, in music, that thin, black covering of wood laid over the neck of a violin, violincello, &c. on which, in performance, the strings are pressed by the fingers of the left hand, while the right manages the bow.

FINGERING, in music, the art of disposing the fingers in a convenient, natural, and apt manner, in the performance of any instrument, but more especially the organ and piano-forte. One of the first things that a skilful master teaches is good-fingering, and to attain this, a pupil should spare no pains, so as to be able to give passages with articulation, accent, and expression.

FINGERS, the extreme part of the hand, divided into five members. See Anatomy. The names of the fingers, reckoning from the thumb, are, 1. Pollex, 2. Index. 3. Medius. 4. Annularis. 5. Auricularis.

FINING, or *Refining*. See Clarification and Refining.

FINITE, something bounded or limited, in contradistinction to infinite.

FIRE. The word heat has been used with so much precision by Doctors Black, Irvine, Crawford, and others, that the word fire seems to have been rendered of little use, except to denote a mass of matter in a state of combustion, which is, indeed, its vulgar acceptation. The term has, however, been used by many eminent writers, to denote what these great philosophers call the matter of heat, now generally termed Caloric, which see.

Fire, *balls of*, in meteorology, a kind of luminous bodies, generally appearing at a great height above the earth, with a splendour surpassing that of the moon; and sometimes equalling her apparent size. They generally proceed in this hemisphere from north to south with vast velocity, frequently breaking into several smaller ones, sometimes vanishing with a report, sometimes not. These luminous appearances no doubt constitute one part of the ancient prodigies, blazing-stars, or comets, which last they sometimes resemble in being attended with a train; but frequently they appear with a round and well defined disk. The first of these, of which we have any accurate account, was observed by Dr. Halley and some other philosophers, at different places, in the year 1719. From the slight observations they could take of its course among the stars, the perpendicular height of this body was computed at about seventy miles from the surface of the earth. The height of others has also been computed, and found to be various: though in general it is supposed to be beyond the limits assigned to our atmosphere, or where it loses its refractive power. The most remarkable of these on record appeared on the 18th of August 1783, about 9 o'clock in the evening. It was seen to the northward of Shetland, and took a southerly direction for an immense space, being observed as far as the southern provinces of France, and one account says, that it was seen at Rome also. During its course it appeared frequently to have changed its shape; sometimes appearing in the form of one ball, sometimes of two or more; sometimes with a train, sometimes without one. It passed over Edinburgh nearly in the zenith, and had then the appearance of a well-defined round body, extremely luminous, and of a greenish colour; the light which it diffused on the ground giving likewise a greenish cast to objects. After passing the zenith it was attended by a train of considerable length, which, continually augmenting, at last obliterated the head entirely; so that it looked like a wedge flying with the obtuse end foremost. The motion was not apparently swift, by reason of its great height; though in reality it must have moved

with great rapidity, on account of the vast space it travelled over in a short time. In other places its appearance was very different. At Greenwich, we are told, that two bright balls parallel to each other led the way, the diameter of which appeared to be about two feet; and were followed by an explosion of eight others, not elliptical, seeming gradually to mutilate, for the last was small. Between each two balls a luminous serrated body extended, and at the last a blaze issued, which terminated in a point. Minute particles dilated from the whole. The balls were tinted first by a pure bright light, then followed a tender yellow, mixed with azure, red, green, &c; which, with a coalition of bolder tints, and a reflection from the other balls, gave the most beautiful rotundity and variation of colours that the human eye could be charmed with. The sudden illumination of the atmosphere, and the form and singular transition of this bright luminary, tended much to make it awful: nevertheless, the amazing vivid appearance of the different balls, and other rich connective parts not very easy to delineate, gave an effect equal to the rainbow in the full zenith of its glory.

Fire, *extinguishing of.* The world has long been of an opinion, that a more ready way than that in general use might be found for extinguishing fires in buildings: and it has been generally attempted upon the doctrine of explosion, Zachary Greyl was the first person who put this plan into execution with any tolerable degree of success. He contrived certain engines, easily manageable, which he proved, before some persons of the first rank, to be of sufficient efficacy, and offered to discover the secret by which they were contrived for a large premium, given either from the crown, or raised by a subscription of private persons. But the scheme meeting with no better success than things of this nature usually do, he died without making the discovery. Two years after this, the person who had his papers found the method, and it was shown before the King of Poland and a great concourse of nobility at Dresden, and the secret purchased at a very considerable price. Afterwards, the same person carried the invention to Paris, and many other places, and practised it every where with success. The secret was this: A wooden vessel was provided, holding a very considerable quantity of water: in the centre of this was fixed a case made of iron plates, and filled with gun-powder; from this vessel to the head of the larger vessels containing the water, there was conveyed a tube or pipe, which might convey the fire very readily through the water to the gunpowder contained in the inner vessel. This tube was filled with a preparation easily taking fire, and quickly burning away; and the manner of using the thing was, to convey it into the room or building where the fire was, with the powder in the tube lighted. The consequence of this was, that the powder in the inner case soon took fire, and with a great explosion burst the vessel to pieces, and dispersed the water every way: thus was the fire put out in an instant, though the room was flaming before in all parts at once. The advantage of this invention was, that, at a small expense, and with the help of a few people, a fire in its beginning might be extinguished; but the thing was not so general as it was at first expected that it would prove, for though of certain efficacy in a chamber or close building, where a fire had but newly begun, yet when the mischief has increased so far that the house was fallen in, or the top open, the machine had no effect.

Fire *in chimneys, method of extinguishing.* It is well known, that the inner parts of chimneys easily take fire; the soot that kindles therein emits a greater flame, according as the tunnel is more elevated, because the current of air feeds the fire. If this current could therefore be suppressed, the fire would soon be extinguished. In order to this, some discharge a pistol into the chimney, which produces no effect. Water thrown into the chimney at the top is equally useless, because it comes down through the middle of the tunnel, and not along the sides. It would be more advisable to stop, with a wet blanket, the upper orifice of the tunnel; but the surest and readiest method is, to apply the blanket either to the throat of the chimney, or over the whole front of the fire-place. If there happens to be a chimney-board or a register, nothing can be so effectual as to apply them immediately; and having by that means stopped the draught of air from below, the burning soot will be put out as readily and as completely as a candle is put out by an extinguisher, which acts exactly upon the same principle. Mr. Smart's machine for sweeping chimneys is admirably adapted to extinguish those that are on fire. See Chimney-*sweeping.*

Fire, *securing buildings against.* Dr. Hales proposes to check the progress of fires by covering the floors of the adjoin-

ing rooms with earth. The proposal is founded on an experiment which he made with a fir board half an inch thick, part of which he covered with an inch depth of damp garden-mould, and then lighted a fire on the surface of the mould; though the fire was kept up by blowing, it was two hours before the board was burnt through, and the earth prevented it from flaming. The thicker the earth is laid on the floors, the better: however, Dr. Hales apprehends that the depth of an inch will generally be sufficient: and he recommends to lay a deeper covering on the stairs, because the fire commonly ascends by them with the greatest velocity. Mr. David Hartley made several trials in the years 1775 and 1776, in order to evince the efficacy of a method which he had invented for restraining the spread of fire in buildings. For this purpose, thin iron plates were well nailed to the tops of the joists, &c. the edges of the sides and ends being lapped over, folded together, and hammered close. Partitions, stairs, and floors, may be defended in the same manner; and plates applied to one side have been found sufficient. The plates are so thin as not to prevent the floor from being nailed on the joists, in the same manner as if this preventive was not used; they are kept from rust by being painted or varnished with oil and turpentine. The expense of this addition, when extending through a whole building, is reckoned at about five per cent. Mr. Hartley had a patent for this invention, and parliament voted a sum of money towards defraying the expense of his numerous experiments. The same preservative may also be applied to ships, furniture, &c. Mr. Hartley's patent has long since expired. Earl Stanhope also discovered and published a very simple and effectual method of securing every kind of building against fire. This method he has divided into three parts, *viz.* under-flooring, extra-lathing, and inter-securing The method of under-flooring is either single or double. In single under-flooring, a common strong lath of oak or fir, about one fourth of an inch thick, should be nailed against each side of every joist, and of every main timber supporting the floor which is to be secured. Other similar laths are then to be nailed along the whole length of the joists, with their ends butting againat each other. The top of each of these laths or fillets ought to be at $1\frac{1}{2}$ inch below the top of the joists or timbers against which they are nailed; and they will thus form a sort of small ledge on each side of all the joists. These fillets are to be well bedded in a rough plaster hereafter mentioned, when they are nailed on, so that there may be no interval between them and the joists; and the same plaster ought to be spread with a trowel upon the tops of all the fillets, and along the sides of that part of the joists which is between the top of the fillets and the upper edge of the joists. In order to fill up the intervals between the joists that support the floor, short pieces of common laths, whose length is equal to the width of these intervals, should be laid in the contrary direction to the joists, and close together in a row, so as to touch one another; their ends must rest upon the fillets, and they ought to be well bedded in the rough plaster, but are not to be fastened with nails. They must then be covered with one thick coat of the rough plaster, which is to be spread over them to the level of the tops of the joists; and in a day or two this plaster should be trowelled over close to the sides of the joists, without covering the tops of the joists with it. In the method of double-flooring, the fillets and short pieces of laths are applied in the manner already described; but the coat of rough plaster ought to be little more than half as thick as that in the former method. Whilst this rough plaster is laid on, some more of the short pieces of laths above-mentioned must be laid in the intervals, between the joists upon the first coat, and be dipped deep in it. They should be laid as close as possible to each other, and in the same direction with the first layer of short laths. Over this second layer of short laths there must be spread another coat of rough plaster, which should be trowelled level with the tops of the joists without rising above them. The rough plaster may be made of coarse lime and hair; or, instead of hair, hay chopped to about three inches in length may be substituted with advantage. One measure of common rough sand, two measures of slacked lime, and three measures of chopped hay, will form in general a very good proportion, when sufficiently beaten up together in the manner of common mortar. The hay should be put in after the two other ingredients are well beaten up together with water. This plaster should be made

stiff; and when the flooring-boards are required to be laid down very soon, a fourth or fifth part of quick-lime in powder, formed by dropping a small quantity of water on the limestone a little while before it is used, and well mixed with this rough plaster, will cause it to dry very fast. If any cracks appear in the rough plaster-work near the joist when it is thoroughly dry, they ought to be closed by washing them over with a brush wet with mortar-wash; this wash may be prepared by putting two measures of quicklime and one of common sand in a pail, and stirring the mixture with water, till the water becomes of the consistence of a thin jelly. Before the flooring-boards are laid, a small quantity of very dry common sand should be strewed over the plaster-work, and struck smooth with a hollow rule, moved in the direction of the joists, so that it may lie rounding between each pair of joists. The plaster-work and sand should be perfectly dry before the boards are laid, for fear of the dry-rot. The method of under-flooring may be successfully applied to a wooden staircase; but no sand is to be laid upon the rough plaster-work. The method of extra-lathing may be applied to ceiling joists, to sloping roofs, and to wooden partitions. The third method, which is that of inter-securing, is very similar to that of under-flooring; but no sand is afterwards to be laid upon it. Inter-securing is applicable to the same parts of a building as the method of extra-lathing, but it is seldom necessary. The author of this invention made several experiments, in order to demonstrate the efficacy of these methods. In most houses it is only necessary to secure the floors; and the extra expense of under-flooring, including all materials, was at that time only about ninepence per square yard, and with the use of quick-lime a little more. The extra expense of extra-lathing is no more than sixpence per square yard for the timber, side walls and partitions; but for the ceiling about ninepence per square yard. But in most houses no extra-lathing is necessary.

Fire, in the art of war, a word of command to the soldiers, to discharge their muskets; to the cavalry, to discharge their carbines or pistols; to the grenadiers, to fire their grenadoes; and to the gunners, to fire the guns.

Fire, *running*, is when a rank of men, drawn up, fire one after another: or, when the lines of an army are drawn out to fire on account of a victory, each squadron or battalion takes it from another, from the right of the first line to the left, and from the left to the right of the second line.

Fire *arms*, are all sorts of arms charged with powder and ball, as cannon, musquets, carabines, pistols, blunderbusses, &c. See Cannon, Gun, &c.

Fire *ball*, in the art of war, a composition of meal-powder, sulphur, salt-petre, pitch, &c. about the bigness of a hand-grenade, coated over with flax, and primed with a slow composition of a fusee. This is to be thrown into the enemy's works in the night-time, to discover where they are; or to fire houses, galleries, or blinds of the besiegers; but they are then armed with spikes, or hooks of iron, that they may not roll off, but stick or hang where they are designed to have any effect.

Fire *pots*, in the military art, small earthen pots, into which is put a charged grenade, and over that powder enough till the grenade is covered; then the pot is covered with a piece of parchment, and two pieces of match across lighted: this pot being thrown by a handle of match where it is designed, it breaks and fires the powder, and burns all that is near it, and likewise fires the powder in the grenade, which ought to have no fuse, to the end its operations may be the quicker.

Fire *ship*, in the navy, a vessel charged with artificial fire-works, which, having the wind of an enemy's ship, grapples her, and sets her on fire.

Fire *engine*. See Engine.

FIRKIN, an English measure of capacity for things liquid, being the fourth part of the barrel: it contains nine gallons of beer.

FIRLOT, a dry measure used in Scotland. The oat-firlot contains 21¼ pints of that country; the wheat firlot contains about 2,211 cubical inches; and the barly-firlot, 31 standard pints. Hence it appears that the Scotch wheat-firlot exceeds the English bushel by 33 cubical inches.

FIRMAMENT, in the Ptolemaic astronomy, the eighth heaven or sphere, with respect to the seven spheres of the planets which it surrounds. It is supposed to have two motions, a diurnal motion, given to it by the primum mobile, from east to west about the poles of the ecliptic; and another opposite

motion from west to east, which last it finishes, according to Tycho, in 25,412 years: according to Ptolemy, in 36,000; and according to Copernicus, in 25,800; in which time the fixed stars return to the same points in which they were at the beginning. This period is commonly called the Platonic year, or the great year.

FIRST *fruits* and *tenths*, in law. First fruits are the profits of every spiritual living for one year; and tenths are the tenth of the yearly value of such living, given anciently to the Pope throughout all Christendom; but by stat. 26 Henry VIII. c. 3. transferred to the King of England. By stat. 27 Henry VIII. c. 3. no tenths are to be paid for the first year, as then the first fruits are due; and by several statutes in the reign of Queen Anne, benefices under 50*l.* per ann. shall be discharged of the payment of first fruits and tenths. She also restored the profits of this revenue to the church, by establishing a perpetual fund therefrom, vested in trustees, for the augmentation of poor livings under 50*l.* a year. This is called Queen Anne's bounty, and is further regulated by subsequent statutes; but as the number of livings under 50*l.* was at the commencement of it 5,597, averaged at 23*l.* per ann. its operation will be very slow.

FISC, in the civil law, the treasury of a prince. It differs from the ærarium, which was the treasury of the public or people: thus, when the money arising from the sale of condemned persons' goods was appropriated for the use of the public, their goods were said *publicari*; but when it was destined for the support of the prince, they were called *confiscari.*

FISCAL, in the civil law, something relating to the pecuniary interest of the prince or people. The officers appointed for the management of the fisc were called *procuratores fisci*, and *advocati fisci*; and among the cases enumerated in the constitutions of the empire, where it was their business to plead, one is against those who have been condemned to pay a fine to the fisc, on account of their litigiousness, or frivolous appeals.

FISH, in natural history, constitutes a class of animals which have no feet, but always fins; add to this, that their body is either altogether naked, or only covered with scales; and that they are aquatic animals, which live mostly, if not always, in water. See PISCES.

FISH, in law, the property in fish in a river is in the lord of the manor, where he has the soil on both sides; but where the river ebbs and flows, and is an arm of the sea, it is common to all, and he who claims a privilege must prove it. To secure the property of fish in ponds, or drains, there are several statutes creating offences and enacting punishments with respect to them, which are too numerous to be here mentioned.

FISHES, in heraldry, are the emblems of silence and watchfulness, and are borne either upright, imbowed, extended, endorsed respecting each other, surmounting one another, fretted, &c.

In blazoning fishes, those borne feeding should be termed devouring; all fishes borne upright, and having fins, should be blazoned hauriant; and those borne transverse the escutcheon must be termed naiant.

FISHERY, a place where great numbers of fish are caught.

The principal fisheries for salmon, herring, mackarel, pilchards, &c. are along the coasts of England, Scotland, and Ireland; for cod, on the banks of Newfoundland; for whales, about Greenland; and for pearls, in the East and West Indies.

FISHERY denotes also the commerce of fish, more particularly the catching them for sale.

Were we to enter into a very minute and particular consideration of fisheries, as at present established in this kingdom, this article would swell beyond its proper bounds; because to do justice to a subject of that concernment to the British nation, requires a very ample and distinct discussion. We shall, however, observe, that since the coasts of Great Britain and Ireland abound with the most valuable fish; and since fisheries, if successful, become permanent nurseries for breeding expert seamen; it is a duty we owe to our country, for its natural security, to extend this trade to the utmost. No nation can have a navy, where there is not a fund of business to breed and employ seamen, without any expense to the public; and no trade is so well calculated for training up these useful members of this society as fisheries.

The situation of the British coasts is the most advantageous for catching fish in the world; the Scottish islands, particularly those to the north and west, lie most commodious for carrying on the fishing trade to perfection; for no country in Europe can pretend to come up to Scotland in the abundance of the finest

fish, with which its various creeks, bays, rivers, lakes, and coasts, are replenished. King Charles I. was so sensible of the great advantages to be derived from fisheries, that he began the experiment, together with a company of merchants, but the civil war soon occasioned that project to be set aside. King Charles II. made a like attempt, but his pressing wants made him withdraw what money he had employed that way; whereupon the merchants that joined with him did so too. Since the union, several attempts have been made to retrieve the fisheries, and a corporation settled to that effect, entitled the Royal British Fishery.

In the year 1750, the parliament of Great Britain taking the state of the fisheries into consideration, an act was passed for the encouragement of the white herring fishery, granting a charter, whereby a corporation is created, to continue twenty-one years, by the name of the Society of the Free British Fishery, to be under the direction of a governor, president, vice-president, council, &c. who are to continue in office the space of three years, with power to make by-laws, &c. and to raise a capital of 500,000*l* by way of subscription. And any number of persons, who, in any part of Great Britain, shall subscribe 10,000*l*. into the stock of this society, under the name of the Fishing Chamber, and carry on the said fishery on their own account of profit and loss, shall be entitled to the same bounty allowed to the society. The bounty is 30*s*. the ton, to be paid yearly, for fourteen years, besides three per cent. for the money advanced by each chamber. The act contains other proper regulations relative to the nets, marks on the herring-barrels, number of hands, and the quantity of salt that is entitled to the bounty, &c. It is then by the encouragement given by this act, that we now see a laudable emulation prevailing all over the two kingdoms, and fishing busses fitted out from almost every port, in order to repair to the Shetland islands, where the herring fishery is carried on with an ardour becoming so important a branch of trade. Scotland, which suffered incredibly from the neglect of this valuable and natural produce of the seas, has not been backward to join in a scheme that tends so evidently to its own advantage: for the cities of Edinburgh and Glasgow, the towns of Montrose, Dundee, Perth, Inverness, and some other boroughs, have raised the proper sum, and chambers have been erected in each of them; the gentlemen of estates, adjoining to the respective places above-mentioned, liberally contributing with merchants towards the prosecution of an undertaking so visibly tending to the good of their country in general.

Fishery, *anchovy*. Anchovies are fished on the coast of Provence, in the months of May, June, and July, at which season shoals of this fish regularly come into the Mediterranean through the Streights of Gibraltar. They are likewise found in plenty in the river of Genoa, on the coast of Sicily, and on that of the island of Gorgone opposite to Leghorn; these last are reckoned the best. It is remarkable that anchovies are seldom fished but in the night time. If a fire be kindled on the poops of the vessels used for this fishing, the anchovies will come in greater numbers into the nets; but then it is asserted, that the anchovies taken thus by fire are neither so good nor so firm, and will not keep so well, as those which are taken without fire. When the fishery is over, they pull off the heads of all the anchovies, gut them, and afterwards range them in barrels of different weights, the largest of which do not weigh above twenty-five or twenty-six pounds, and they put a good deal of salt in them. Some also pickle them in small earthern pots, made on purpose, of two or three pounds weight, more or less, which they cover with plaster, to keep them the better.

Fishery, *cod*. There are two kinds of cod-fish, the one green or white cod, and the other dried or cured cod, though it is all the same fish differently prepared; the former being sometimes salted and barrelled, then taken out for use; and the latter, having lain some considerable time in salt, dried in the sun or smoke. We shall therefore speak of each of these apart, and first of

Fishery, *green cod*. The chief fisheries for Green cod are in the bay of Canada, on the great bank of Newfoundland, and on the isle of St. Peter, and the isle of Sable, to which places vessels resort from divers parts, both of Europe and America. They are from 100 to 150 tons burthen, and will catch between 30 and 40 thousand cod each. The most essential part of the fishery is to have a master who knows how to cut up the cod, one who is skilled to take the head off properly, and, above all, a good salter, on which the preserving them, and consequently the success of the voyage, depends. The best season is from the beginning of February to the end of April; the fish, which in the winter retire to the

deepest water, coming then on the banks, and fattening extremely. What is caught from March to June keeps well, but those taken in July, August, and September, when it is warm on the banks, are apt to spoil soon. Every fisher takes but one at a time; the most expert will take from 350 to 400 in a day, but that is the most, the weight of the fish, and the great coldness on the bank, fatiguing very much. As soon as the cod are taken, the head is taken off; they are opened, gutted, and salted, and the salter stows them in the bottom of the hold, head to tail, in beds a fathom or two square, laying layers of salt and fish alternately, but never mixing fish caught on different days. When they have lain thus three or four days to drain off the water, they are replaced in another part of the ship, and salted again; where they remain till the vessel is loaded. Sometimes they are cut in thick pieces, and put up in barrels, for the conveniency of carriage.

Fishery, *dry cod.* The principal fishery for dry cod is from Cape Rose to the Bay des Exports, along the coast of Placentia, in which compass there are divers commodious ports for the fish to be dried in. These, though of the same kind with the fresh cod, are much smaller, and therefore fitter to keep, as the salt penetrates more easily into them. The fishery of both is much alike, only this latter is more expensive, as it takes up more time, and employs more hands, and yet scarce half so much salt is spent in this as in the other. The bait is herrings, of which great quantities are taken on the coast of Placentia. When several vessels meet, and intend to fish in the same port, he whose shallop first touches ground becomes entitled to the quality and privileges of admiral: he has the choice of his station, and the refusal of all the wood on the coast at his arrival. As fast as the masters arrive, they unrig all their vessels, leaving nothing but the shrouds to sustain the masts, and in the mean time the mates provide a tent on shore, covered with branches of trees, and sails over them, with a scaffold of great trunks of pines, twelve, fifteen, sixteen, and often twenty feet high, commonly from forty to sixty feet long, and about one third as much in breadth. While the scaffold is preparing, the crew are fishing, and as fast as they catch they bring their fish ashore; open and salt them upon moveable benches; but the main salting is performed on the scaffold. When the fish have taken salt, they wash and hang them to drain on rails; when drained, they are laid on kinds of stages, which are small pieces of wood laid across, and covered with branches of trees, having the leaves stripped off for the passage of the air. On these stages they are disposed, a fish thick, head against tail, with the back uppermost, and are turned carefully four times every twenty-four hours. When they begin to dry, they are laid in heaps ten or twelve thick, in order to retain their warmth; and every day the heaps are enlarged, till they become double their first bulk; then two heaps are joined together, which they turn every day as before; lastly, they are salted again, beginning with those first salted, and being laid in huge piles, they remain in that situation till they are carried on board the ships, where they are laid on the branches of trees disposed for that purpose upon the ballast, and round the ship, with mats, to prevent their contracting any moisture.

There are four kinds of commodities drawn from cod, *viz.* the sounds, the tongues, the roes, and the oil extracted from the liver. The first is salted at the fishery, together with the fish, and put up in barrels from 6 to 700 pounds. The tongues are done in like manner, and brought in barrels from 4 to 500 pounds. The roes are also salted in barrels, and serve to cast into the sea to draw fish together, and particularly pilchards. The oil comes in barrels, from 400 to 520 pounds, and is used in dressing leather. The Scots catch a small kind of cod on the coast of Buchan, and all along the Murray Firth on both sides; as also in the Firth of Forth, Clyde, &c. which is much esteemed. They salt and dry them in the sun upon rocks, and sometimes in the chimney. They also cure skait, and other smaller fish in the same manner, but most of these are for home consumption.

Fishery, *coral.* See Coral *fishery.*

Fishery, *herring.* Herrings are chiefly found in the North Sea. They are a fish of passage, and commonly go in shoals, being very fond of following fire or light, and in their passage they resemble a kind of lightning. About the beginning of June, an incredible shoal of herrings, probably much larger than the land of Great Britain and Ireland, come from the north on the surface of the sea: their approach is known by the hovering of sea fowl in expectation of prey, and by the smoothness of the water; but where they breed, or what particular place they come from, cannot be easily

discovered. As this great shoal passes between the shores of Greenland and the North Cape, it is necessarily probably confined, and as it reaches the extremities of Great Britain, is divided into two parts. For we find one part of the herring steering west, or south-west, and leaving the islands of Shetland and Orkney to the left, pass on towards Ireland, where, being interrupted a second time, some keeping the shore of Britain, pass away south, down St. George's channel; while the other part, edging off to the south-west, coast the western ocean, till they reach the south shore of Ireland, and then steering south-east, join the rest in St. George's channel. The other part of the first division made in the north, parting a little to the east and south-east, pass by Shetland, and then make the point of Buchan-ness, and the coast of Aberdeen, filling, as they go, all the bays, firths, creeks, &c. with their innumerable multitudes. Hence they proceed forward, pass by Dunbar, and rounding the high shores of St. Abbe's Head and Berwick, are seen again off Scarborough; and even then not diminished in bulk, till they come to Yarmouth-Roads, and from thence to the mouth of the Thames, after which, passing down the British channel, they seem to be lost in the Western Ocean.

The vast advantage of this fishery to our nation is very obvious, when we consider that, though herrings are found upon the shores of North America, they are never seen there in such quantities as with us, and that they are not to be met with in considerable numbers in any of the southern kingdoms of Europe, as Spain, Portugal, or the southern parts of France; on the side of the ocean, or in the Mediterranean, or on the coast of Africa. There are two seasons for fishing herring, the first from June to the end of August, and the second in autumn, when the fogs become very favourable for this kind of fishing. The Dutch begin their herring-fishing on the 24th of June, and employ no less than 2000 vessels therein, called busses, being between 45 and 60 tons burden, and carrying three or four small cannon. They never stir out of port without a convoy, unless there be enough together to make about 18 or 20 cannon among them, in which case they are allowed to go in company. Before they go out, they make a verbal agreement, which has the same force as if it were in writing. The regulations of the admiralty of Holland are partly followed by the French, and other nations, and partly improved and augmented with new ones, as, that no fisher shall cast his net within a hundred fathoms of another boat: that while the nets are cast, a light shall be kept on the hind part of the vessel: that when a boat is obliged to leave off fishing, the light shall be cast into the sea: that when the greater part of a fleet leaves off fishing and casts anchor, the rest shall do the same, &c. By the late act of parliament in Great Britain, the regulations are, that every vessel entitled to the bounty must carry twelve Winchester bushels of salt in new barrels, for every last of fish such vessel is capable of holding; and as many more new barrels as such vessels can carry, and two fleets of tanned nets; that is, a vessel of seventy tons shall carry one fleet of 50 nets, each net to be 30 yards full upon its rope, and seven fathoms deep; and so in proportion for greater or smaller vessels; and be provided with one other fleet of 50 like nets, on board a tender, or left on shore in a proper place, for the use of the said vessel, &c.

There is nothing particular in the manner of fishing. The nets wherein the fish are drawn should regularly have their meshes an inch square, to let all the lesser fry go through.

Curing and preparing herring. The commerce of herring, both white or pickled, and red, is very considerable. The white Dutch herrings are the most esteemed, being distinguished into four sorts, according to their sizes; and the best are those that are fat, fleshy, firm, and white, salted the same day they are taken with good salt, and well barrelled. The British herrings are little inferior, if not equal, to the Dutch; for in spite of all their endeavours to conceal the secret, their method of curing, lasting, or casking the herrings, has been discovered, and is as follows:—After they have hauled in their nets, which they drag in the sterns of their vessels backward and forwards in traversing the coast, they throw them upon the ship's deck, which is cleared of every thing for that purpose; the crew is separated into sundry divisions, and each division has a peculiar task: one part opens and guts the herrings, leaving the melts and roes: another cures and salts them, by lining or rubbing their inside with salt: the next packs them, and between each row and division they sprinkle handfuls of salt; lastly, the cooper puts the finishing hand to all, by heading the casks very tight, and stowing them in the hold. It is customary with us to wash

the herring in fresh water, and steep them 12 or 15 hours in a strong brine, before we proceed to barrel them.

Red Herrings must lie 24 hours in the brine, in as much as they are to take all their salt there, and when they are taken out, they are spitted, that is, strung by the head on little wooden spits, and then hung in a chimney made for that purpose. After which a fire of brushwood, which yields a deal of smoke, but no flame, being made under them, they remain there till sufficiently smoked and dried, and are afterwards barrelled up for keeping.

Fishery, *mackerel*. The mackerel are found in large shoals in the ocean, but especially on the French and English coasts. They enter the English channel in April, and proceeding as the summer advances, about June they are on the coasts of Cornwall, Sussex, Normandy, Picardy, &c. where the fishery is most considerable. They are taken either with a line or nets: the latter is preferable, and is usually performed in the night time. They are pickled two ways, first by opening and gutting them, and cramming their bellies as hard as possible with salt, by means of a stick, and then laying them in rows at the bottom of the vessel, strewing salt between each layer. The second way is putting them directly into tubs full of brine, made of salt and fresh water, and leaving them to steep till they have taken salt enough to keep. After this, they are barrelled up and pressed close down.

Fishery, *pearl*. See Pearl *fishery*.

Fishery, *pilchard*. The chief pilchard fisheries are along the coasts of Dalmatia, on the coast of Bretagne, and along the coasts of Cornwall and Devonshire. That of Dalmatia is very plentiful: that on the coasts of Bretagne employs annually about 300 ships. The pilchards caught on our coasts, though bigger, are not so much valued as those on the coasts of France, owing principally to their not being so thoroughly cured. They naturally follow the light, which contributes much to the facility of the fishery: the season is from June to September. On the coasts of France they make use of the roes of the cod-fish as a bait, which, thrown into the sea, makes them rise from the bottom, and run into the nets: on our coasts there are persons posted ashore, who, spying by the colour of the water where the shoals are, make signs to the boats to go among them to cast their nets. When taken, they are brought on shore to a warehouse, where they are laid up in broad piles, supported with backs and sides, and as they are piled they salt them with bay salt, in which lying to soak 20 or 30 days, they run out a deal of blood, with dirty pickle and bittern: then they wash them clean in sea-water; and when dry barrel and press them hard down, to squeeze out the oil, which issues out at a hole in the bottom of the cask. The Cornish men observe of the pilchard, that it is the least fish in size, most in number, and greatest for gain, of any they take out of the sea.

Fishery, *salmon*. The chief salmon fisheries in Europe are in England, Scotland, and Ireland, in the rivers and sea-coasts adjoining to the river mouths. Those most distinguished for salmon in Scotland are, the river Tweed, the Clyde, the Tay, the Dee, the Don, the Spey, the Ness, the Bewley, &c. in most of which it is very common about the height of summer, especially if the weather happen to be very hot, to catch four or five score of salmon at a draught. The chief rivers in England for salmon are, the Tyne, the Trent, the Severn, and the Thames. The fishing usually begins about January, and in Scotland they are obliged to give over about the 15th of August, because, as it is then supposed the fish come up to spawn, it would be quite depopulating the rivers to continue fishing any longer. It is performed with nets, and sometimes with a kind of locks or wears made on purpose, which in certain places have iron or wooden grates so disposed, in an angle, that being impelled by any force in a contrary direction to the course of the river, they may give way and open a little at the point of contact, and immediately shut again, closing the angle. The salmon, therefore, coming up into the rivers, are admitted into these grates, which open, and suffer them to pass through, but shut again, and prevent their return. Salmon are also caught with a spear, which they dart into him when they see him swimming near the surface of the water. It is customary likewise to catch them with a candle and lanthorn, or a wisp of straw set on fire; for the fish, naturally following the light, are struck with the spear, or taken in a net spread for that purpose, and lifted with a sudden jerk from the bottom. We make no mention of the method of catch-

salmon with a line and hook, because it is much the same with trout fishing.

Curing salmon. When the salmon are taken, they open them along the back, take out the guts and gills, and cut out the greatest part of the bones, endeavouring to make the inside as smooth as possible, then salt the fish in large tubs for the purpose, where they lie a considerable time soaking in brine, and about October they are packed close up in barrels, and sent to London, or exported up the Mediterranean. They have also in Scotland a great deal of salmon salted in the common way, which, after soaking in brine a competent time, is well pressed, and then dried in smoke; this is called kipper, and is chiefly made for home consumption, and if properly cured and prepared is reckoned very delicious.

Fishery, *sturgeon.* The greatest sturgeon fishery is in the mouth of the Volga, on the Caspian Sea, where the Muscovites employ a great number of hands, and catch them in a kind of enclosure formed by huge stakes, representing the letter Z, repeated several times. These fisheries are open on the side next the sea, and close on the other, by which means, the fish ascending in the season up the river are embarrassed in these narrow angular retreats, and thus are easily killed with a harping-iron. Sturgeons, when fresh, eat deliciously; and in order to make them keep, they are salted or pickled in large pieces, and put up in kegs from thirty to fifty pounds. But the great object of this fishery is the roe, of which the Muscovites are extremely fond, and of which is made the cavear or kavia, so much esteemed by the Italians. See Cavear.

Fishery, *whale.* Whales are chiefly caught in the North Sea: the largest sort are found about Greenland or Spitzbergen. At the first discovery of this country, whales, not being used to be disturbed, frequently came into the very bays, and were accordingly killed almost close to the shore, so that the blubber being cut off was immediately boiled into oil on the spot. The ships, in those times, took in nothing but the pure oil and the fins, and all the business was executed in the country, by which means, a ship could bring home the product of many more whales, than she can according to the present method of conducting this trade. The fishery also was then so plentiful, that they were obliged sometimes to send other ships to fetch off the oil they had made, the quantity being more than the fishing ships could bring away. But time and change of circumstances have shifted the situation of this trade. The ships coming in such numbers from Holland, Denmark, Hamburgh, and other northern countries, all intruders upon the English, who were the first discoverers of Greenland, disturbed the whales, and gradually, as other fish often do, forsaking the place, were not to be killed so near the shore as before; but are now found, and have been so ever since, in the openings and spaces among the ice, where they have deep water, and where they go sometimes a great many leagues from the shore.

The whale fishery begins in May, and continues all June and July; but whether the ships have good or bad success, they must come away and get clear of the ice by the end of August; so that in the month of September, at farthest, they may be expected home; but a ship that meets with a fortunate and early fishery in May may return in June or July.

The manner of taking whales at present is as follows: as soon as the fishermen hear the whale blow, they cry out fall! fall! and every ship gets out its long boat, in each of which there are six or seven men: they row till they come pretty near the whale, then the harpooner strikes it with the harpoon. This requires great dexterity, for through the bone of his head there is no striking, but near his spout there is a soft piece of flesh, into which the iron sinks with ease. As soon as he is struck, they take care to give him rope enough, otherwise, when he goes down, as he frequently does, he would inevitably sink the boat: this rope he draws with such violence, that, if it were not well watered, it would, by its friction against the sides of the boat, be soon set on fire. The line fastened to the harpoon is six or seven fathoms long, and is called the fore-runner: it is made of the finest and softest hemp, that it may slip the easier: to this they join a heap of lines of 90 or 100 fathoms each, and when there are not enough in one long boat they borrow from another. The man at the helm observes which way the rope goes, and steers the boat accordingly, that it may run exactly out before: for the whale runs away with the line with so much rapidity, that he would overset the boat if it were not kept straight.

When the whale is struck, the other long boats row before, and observe which way the line stands, and sometimes pull it; if they feel it stiff, it is a sign the whale still pulls in strength, but if it hangs loose, and the boat lies equally high before and behind upon the water, they pull it in gently, but take care to coil it so that the whale may have it again easily, if he recovers strength: they take care, however, not to give him too much line, because he sometimes entangles it about a rock, and pulls out the harpoon. The fat whales do not sink as soon as dead, but the lean ones do, and come up some days afterwards. As long as they see whales, they lose no time in cutting up what they have taken, but keep fishing for others: when they see no more, or have taken enough, they begin with taking off the fat and whiskers in the following manner: the whale being lashed along side, they lay it on one side, and put two ropes, one at the head and the other in the place of the tail, which, together with the fins is struck off as soon as he is taken, to keep those extremities above water. On the off side of the whale are two boats, to receive the pieces of fat, utensils, and men, that might otherwise fall into the water on that side. These precautions being taken, three or four men, with irons at their feet to prevent slipping, get on the whale, and begin to cut out pieces of about three feet thick and eight long, which are hauled up at the capstan or windlass. When the fat is all got off, they cut off the whiskers of the upper jaw with an axe. Before they cut they are all lashed, to keep them firm, which also facilitates the cutting, and prevents them from falling into the sea; when on board, five or six of them are bundled together, and properly stowed, and after all is got off, the carcase is turned adrift, and devoured by the bears, who are very fond of it. In proportion as the large pieces of fat are cut off, the rest of the crew are employed in slicing them smaller, and picking out all the lean. When this is prepared they stow it under the deck, where it lies till the fat of all the whales is on board; then cutting it still smaller, they put it up in tubs in the hold, cramming them very full and close. Nothing now remains but to sail homewards, where the fat is to be boiled, and melted down into train oil.

It were in vain to speak in this place of the advantages that may be derived to Great Britain from the whale fishery. We shall only remark, that the legislature thinks that trade of so great importance as to grant a very considerable bounty for the encouragement of it; for every British vessel of 200 tons or upwards, bound to the Greenland Seas on the whale fishery, if found to be duly qualified according to the act, obtains a license from the commissioners of the customs to proceed on such voyage: and on the ship's return, the master and mate making oath that they proceeded on such voyage and no other, and used all their endeavours to take whales, &c. and that all the whale-fins, blubber, oil, &c. imported in their ship, were taken by their crew in those seas, there shall be allowed 40*s*. for every ton, according to the admeasurement of the ship.

Besides these fisheries, there are several others, both on the coasts of Great Britain and in the North Seas, which, although not much the subject of merchandize, nevertheless employ great numbers both of ships and men; as, 1. The oyster fishing at Colchester, Feversham, the Isle of Wight, in the Swales of the Medway, and in all the creeks between Southampton and Chichester, from whence they are carried to be fed in pits about Wevenhoe and other places. See OYSTER.

2. The lobster fishing all along the British channel, the firth of Edinburgh, on the coast of Northumberland, and on the coast of Norway, from whence great quantities are brought to London. And, lastly, the fishing of the pot-fish, fin-fish, sea-unicorn, sea-horse, and the seal, or dog-fish, all which are found in the same seas with the whales, and yield blubber in a certain degree; besides, the horn of the unicorn is as estimable as ivory, and the skins of the seals are particularly useful to trunk-makers.

FISHING, in general, the art of catching fish, whether by means of nets, or of spears, lines, rods, and hooks. See ANGLING.

FISTULA, in the ancient music, an instrument of the wind kind, resembling our flute, or flageolet. See FLUTE.

FISTULA, in surgery, a deep, narrow, and callous ulcer, generally arising from abscesses. Fistulas differ from sinuses in this, that the former are callous, the latter not. See SURGERY.

FISTULA *lachrymalis*, a disease which

attacks the great caruncle in the inward corner of the eye.

FISTULARIA, the *tobacco-pipe fish*, in natural history, a genus of fihes of the order Abdominales. Generic character: snout cylindrical; jaws distant from the eyes; gill membrane with seven rays; body tapering from the jaws to the tail. There are three species. F. tabacaria, or the slender fistularia, grows to the length of three feet, and is found on the coasts of America. By the inhabitants of Brazil it is eaten, though not particularly esteemed by them. It lives principally upon smaller fishes, insects, and worms. These it obtains with great ease, by means of its snout, which it introduces into clefts, and under stones, where they mostly abound. The two other species are natives of the Indian seas.

FITCHEE, in heraldry, a term applied to a cross, when the lower end of it is sharpened into a point.

FITS *of easy reflection*, &c. in optics. Sir Isaac Newton calls the successive disposition of a ray to be reflected through different thicknesses of a plate of air, or any other substance, the returns or fits of easy reflection, and the disposition of the same ray to be transmitted in the same manner through the intervening spaces, returns or fits of easy transmission. Thus, a ray of light is in a fit of easy reflection, when it falls on a plate of any kind of matter, whose thickness is one of the terms of the series 1, 3, 5, 7, &c. taking the smallest thickness capable of reflecting such ray for unit; and, in the same way, it is in one of its fits of easy transmission, when the thickness is one of the terms of the series 2, 4, 6, 8, &c. See Optics.

FIXED *bodies*, are those which bear a considerable degree of heat, without evaporating or losing any of their weight.

FIXITY. The property by which bodies resist the action of heat, so as not to rise in vapour. It is the opposite to volatility. The fixity of bodies appears to be merely relative, and depends on the temperature at which they assume the elastic state or form. Such bodies as assume this state at a low temperature will easily rise; whereas those which cannot be so dilated but at an extreme heat will remain fixed in all ordinary situations. From the analogy of a variety of facts, it does not seem probable that any substances are absolutely fixed.

FLACOURTIA, in botany, so called in memory of Stephen de Flacourt, a genus of the Dioecia Polyandria class and order. Natural order of Tiliaceæ, Jussieu. Essential character: male, calyx five-parted; corolla none; stamens very numerous; female, calyx many-leaved; corolla none: germ superior; styles five to nine; berry many celled. There is but one species.

FLAG, a general name for colours, standards, antients, banners, ensigns, &c. which are frequently confounded with each other. The fashion of pointed or triangular flags, as now used, Rod. Toletan assures, came from the Mahometan Arabs, or Saracens, upon their seizing of Spain, before which time all the ensigns of war were stretched, or extended on cross pieces of wood, like the banners of a church. The pirates of Algiers, and throughout the coasts of Barbary, bear an hexagonal flag.

Flag is more particularly used at sea, for the colours, antients, standards, &c. borne on the tops of the masts of vessels, to notify the person who commands the ship, of what nation it is, and whether it be equipped for war or trade. The admiral in chief carries his flag on the maintop; the vice-admiral on the fore-top; and the rear-admiral on the mizen-top. When a council of war is to be held at sea, if it be on board the admiral, they hang a flag in the main shrouds; if in the vice-admiral, in the fore shrouds; and if in the rear-admiral, in the mizen shrouds.

Besides the national flag, merchant ships frequently bear lesser flags on the mizen mast, with the arms of the city where the master ordinarily resides; and on the foremast, with the arms of the place where the person who freights them lives.

Flag, *to lower or strike the*, is to pull it down upon the cap, or to take it in, out of the respect or submission due from all ships or fleets inferior to those any way justly their superiors. To lower or strike the flag in an engagement, is a sign of yielding.

The way of leading a ship in triumph is to tie the flags to the shrouds, or the gallery, in the hind part of the ship, and let them hang down towards the water, and to tow the vessels by the stern. Livy relates, that this was the way the Romans used those of Carthage.

Flag, *to heave out the*, is to put out or put abroad the flag.

Flag, *to hang out the white*, is to ask quarter; or it shows, when a vessel is arrived on a coast, that it has no hostile intention, but comes to trade, or the like. The red flag is a sign of defiance and battle.

Flag *officers*, those who command the several squadrons of a fleet; such are the admirals, vice-admirals, and rear admiral. The flag-officers in our pay are the admiral, vice-admiral, and rear-admiral, of the white, red and blue.

Flag *ship*, a ship commanded by a general or flag-officer, who has a right to carry a flag, in contradistinction to the secondary vessels under the command thereof.

FLAGELLARIA, in botany, a genus of the Hexandria Trigynia class and order. Natural order of Tripetaloideæ. Asparagi, Jussieu. Essential character: calyx six-parted; corolla none; berry one-seeded. There are two species.

FLAGEOLET, or Flajeolet, a little flute, used chiefly by shepherds and country people. It is made of box, or other hard wood, and sometimes of ivory, and has six holes besides that at the bottom, the mouth-piece, and that behind the neck. See Flute.

FLAIL, an instrument for thrashing corn. A flail consists of the following parts: 1. The hand-staff, or piece held in the thrasher's hand. 2. The swiple, or that part which strikes out the corn. 3. The caplins, or strong double leathers, made fast to the tops of the hand-staff and swiple. 4. The middle-band, being the leather thong, or fish skin, that ties the caplins together.

FLAIR, in the sea language. When a ship is housed in near the water, so that the work above hangs over too much, it is said to flair over. This makes the ship more roomy aloft, for the men to use their arms.

FLAMBEAU, a kind of large taper, made of hempen wicks, by pouring melted wax on their top, and letting it run down to the bottom. This done, they lay them to dry, after which they roll them on a table, and join four of them together by means of a red-hot iron; and then pour on more wax, till the flambeau is brought to the size required. Flambeaus are of different lengths, and made either of white or yellow wax. They serve to give light in the streets at night, or on occasion of illuminations.

FLAME. Newton and others have considered flame as an ignited vapour, or red-hot smoke. This, in a certain sense, may be true, but, no doubt, it contains an inaccurate comparison. Simple ignition never exceeds in intensity of light the body by contact of which it was produced. But it appears to be well ascertained, that flame always consists of volatile inflammable matter, in the act of combustion, and combination with the oxygen of the atmosphere. Many metallic substances are volatilized by heat, and burn with a flame, by the contact of the air in this rare state. Sulphur, phosphorus, and some other bases of acids, exhibit the same phenomenon. But the flames of organized substances are in general produced by the extrication and ascension of hydrogen gas with more or less of charcoal. When the circumstances are not favourable to the perfect combustion of these products, a portion of the coal passes through the luminous current unburned, and forms smoke. Soot is the condensed matter of smoke.

As the artificial light of lamps and candles is afforded by the flame they exhibit, it seems a matter of considerable importance to society, to ascertain how the most luminous flame may be produced with the least consumption of combustible matter. There does not appear to be any danger of error in concluding, that the light emitted will be greatest when the matter is completely consumed in the shortest time. It is, therefore, necessary, that a stream of volatilized combustible matter, of a proper figure, at a very elevated temperature, should pass into the atmosphere with a certain determinate velocity. If the figure of this stream should not be duly proportioned; that is to say, if it be too thick, its internal parts will not be completely burned, for want of contact with the air. If its temperature be below that of ignition, it will not burn when it comes into the open air. And there is a certain velocity, at which the quantity of atmospherical air which comes in contact with the vapour will be neither too great nor too small: for too much air will diminish the temperature of the stream of combustible matter so much, as very considerably to impede the desired effect; and too little will render the combustion languid.

We have an example of a flame too

large, in the mouths of the chimneys of furnaces, where the luminous part is merely superficial, or of the thickness of about an inch or two, according to circumstances, and the internal part, though hot, will not set fire to paper passed into it through an iron tube, the same defect of air preventing the combustion of the paper, as prevented the interior fluid itself from burning. And in the lamp of Argand, we see the advantage of an internal current of air, which renders the combustion perfect by the application of air on both sides of a thin flame. So likewise a small flame is whiter and more luminous than a larger; and a short snuff of a candle, giving out less combustible matter in proportion to the circumambient air, the quantity of light becomes increased to eight or ten times what a long snuff would have afforded.

FLAMINGO, a bird, otherwise called phœnicopterus. See PHŒNICOPTERUS.

FLAMSTEED (JOHN), in biography, an eminent English astronomer, being indeed the first astronomer royal, for whose use the Royal Observatory was built at Greenwich, thence called Flamsteed House. He was born at Denby, in Derbyshire, the 19th of August, 1646. He was educated at the free school of Derby, where his father lived, and at fourteen years of age was afflicted with a severe illness, which rendered his constitution tender ever after, and prevented him then from going to the university, for which he was intended. He nevertheless prosecuted his school education with the best effect; and then, in 1662, on quitting the grammar-school, he pursued the natural bent of his genius, which led him to the study of astronomy, and closely perused Sacrobosco's book "De Sphæra," which fell in his way, and which laid the ground-work of all that mathematical and astronominal knowledge, for which he became afterwards so justly famous. He next procured other more modern books of the same kind, and, among them, Street's "Astronomia Carolina," then lately published, from which he learned to calculate eclipses and the planets' places. Some of these being shewn to a Mr. Halton, a considerable mathematician, he lent him Riccioli's "Almagestum Novum," and Kepler's "Tabulæ Rudolphinæ," which he profited much by. In 1669, having calculated some remarkable eclipses of the moon, he sent them to Lord Brouncker, president of the Royal Society, which were greatly approved by that learned body, and procured him a letter of thanks from Mr. Oldenburgh, their Secretary, and another from Mr. John Collins, with whom, and other learned men, Mr. Flamsteed for a long time afterwards kept up a correspondence by letters, on literary subjects.

In 1670, his father observing he held correspondence with these ingenious gentlemen, advised him to take a journey to London, to make himself perfectly acquainted with them; an offer which he gladly embraced, and visited Mr. Oldenburgh and Mr. Collins, who introduced him to Sir Jonas Moore, which proved the means of his greatest honour and preferment: he here got the knowledge and practice of astronomical instruments, as telescopes, micrometers, &c. On his return, he called at Cambridge, and visited Dr. Barrow, Mr. Isaac Newton, and other learned men there, and entered himself a student of Jesus College. In 1672, he extracted several observations from Mr. Gascoigne's and Mr. Crabtree's letters, which improved him greatly in dioptrics. In this year he made many celestial observations, which, with calculations of the appulses of the moon and planets to fixed stars for the year following, he sent to Mr. Oldenburgh, who published them in the "Philosophical Transactions."

1673, Mr. Flamsteed wrote a small tract concerning the true diameters of all the planets, when at their greatest and least distances from the earth, which he lent to Mr. Newton in 1685, who made some use of it in the fourth book of his "Principia." In 1674, he wrote an ephemeris to show the falsity of astrology, and the ignorance of those who pretended to it; with calculations of the moon's rising and setting; also occultations and appulses of the moon and planets to the fixed stars. To which, at Sir Jonas Moore's request, he added a table of the moon's southings for that year; from which, and from Philips's "Theory of the Tides," the high-waters being computed, he found the times come very near. In 1674, too, he drew up an account of the tides for the use of the king. Sir Jonas also shewed the King, and the Duke of York, some barometers and thermometers that Mr. Flamsteed had given him, with the

necessary rules for judging of the weather; and otherwise took every opportunity of speaking favourably of Flamsteed to them, till at length he brought him a warrant to be the king's astronomer, with a salary of 100*l.* per annum, to be paid out of the office of ordnance, because Sir Jonas was then surveyor-general of the ordnance. This, however, did not abate our author's propensity for holy orders, and be was accordingly ordained at Ely, by Bishop Gunning.

On the 10th of August 1675, the foundation of the Royal observatory at Greenwich was laid: and, during the building of it, Mr. Flamsteed's temporary observatory was in the queen's house, where he made his observations of the appulses of the moon and planets to the fixed stars, and wrote his "Doctrine of the Sphere," which was afterwards published by Sir Jonas, in his "System of Mathematics."

About the year 1684, he was presented to the living of Burslow in Surry, which he held as long as he lived. Mr. Flamsteed was equally respected by the great men his contemporaries, and by those who have succeeded since his death. Dr. Wotton, in his "Reflections upon Ancient and Modern Learning," styles our author one of the most accurate observers of the planets and stars, and says he calculated tables of the eclipses of the several satellites, which proved very useful to the astronomers; and Mr. Molyneux, in his "Dioptrica Nova," gives him a high character: and in the admonition to the reader, prefixed to the work, observes, that the geometrical method of calculating a ray's progress is quite new, and never before published; and for the first hint of it, says he, I must acknowledge myself obliged to my worthy friend Mr. Flamsteed.

He wrote several small tracts, and had many papers inserted in the "Philosophical Transactions," *viz.* several in almost every volume: and from the fourth to the twenty-ninth, too numerous to be mentioned in this place particularly.

But his great work, and that which contained the main operations of his life, was the "Historia Cœlestis Britannica," published in 1725, in three large folio volumes; the first of which contains the observations of Mr. William Gascoigne, the first inventor of the method of measuring angles in a telescope by means of screws, and the first who applied telescopical sights to astronomical instruments, taken at Middleton, near Leeds in Yorkshire, between the years 1638 and 1643; extracted from his letters by Mr. Crabtree, with some of Mr. Crabtree's observations about the same time; and also those of Mr. Flamsteed himself, made at Derby, between the years 1670 and 1675; besides a multitude of curious observations, and necessary tables, to be used with them, made at the Royal Observatory, between the years 1675 and 1689. The second volume contains his observations, made with a mural arch of near 7 feet radius, and 140 degrees on the limb of the meridional zenith, distances of the fixed stars, sun, moon, and planets, with their transits over the meridian; also observations of the diameters of the sun and moon, with their eclipses, and those of Jupiter's satellites, and variations of the compass from 1689 to 1719, with tables showing how to render the calculation of the places of the stars and planets easy and expeditious; to which are added, the moon's place at her oppositions, quadratures, &c.; also the planets' places, derived from the observations. The third volume contains a catalogue of the right ascensions, polar distances, longitudes, and magnitudes of near 3,000 fixed stars, with the corresponding variations of the same: to this volume is prefixed a large preface, containing an account of all the astronomical observations made before his time, with a description of the instruments employed, as also of his own observations and instruments, with a new Latin version of Ptolemy's "Catalogue of 1026 fixed stars," and Ulegh-beig's "Places" annexed on the Latin page, with the corrections; a small catalogue of the Arabs: Tycho Brahe's of about 780 fixed stars; the Landgrave of Hesse's of 386; Helvetius's of 1534; and a catalogue of some of the southern fixed stars, not visible in our hemisphere, calculated from the observations made by Dr. Halley at St. Helena, adapted to the year 1726.

This work he prepared in a great measure for the press, with much care and accuracy; but through a natural weakness of constitution, and the decline of age, he died of a strangury before he had finished it, December the 19th, 1719, at 73 years of age, leaving the care of finishing and publishing his work to his friend Mr. Hodgson. A less perfect edition of the Historia Cœlestia had before been published without his consent, viz. in

1712, in one volome folio, containing his observations to the year 1705.

Thus then, as Dr. Keil observed, our author, for more than forty years, watched the motions of the stars, and has given us innumerable observations of the sun, moon, and planets, which he made with very large instruments, accurately divided, and fitted with telescopic sights; whence we may rely much more on the observations he has made than on those of formers astronomers, who made their observations with the naked eye, and without the like assistance of telescopes.

FLANKS *of an army*, are the troops encamped on the right and left, as the flanks of a battalion are the files on the right and left.

Flank *of a bastion*, in fortification, that part which joins the face to the curtain.

FLANNEL, a kind of woollen stuff, composed of a woof and warp, and woven after the manner of baize. Various theories have been adopted to prove the utility of flannel as an article of dress: it is unquestionably a bad conductor of heat, and on that account very useful in cold weather; this is accounted for from the structure of the stuff; the fibres touch each other very slightly, so that the heat moves slowly through the interstices, which being already filled with air, give little assistance in carrying off the heat. On this subject Count Rumford has made many experiments, from which it should seem, that though linen, from the apparent ease with which it receives dampness from the atmosphere, appears to have a much greater attraction for water than any other, yet that those bodies which receive water in its unelastic form with the greatest ease, or are most easily wet, are not those which in all cases attract the moisture of the atmosphere with the greatest avidity. "Perhaps," says he, "the apparent dampness of linen to the touch arises more from the ease with which that substance parts with the water it contains, than from the quantity of water it actually holds; in the same manner as a body appears hot to the touch in consequence of its parting freely with its heat, while another body, which is really at the same temperature, but which withholds its heat with great obstinacy, affects the sense of feeling much less violently. It is well known, that woollen clothes, such as flannels, &c. worn next the skin, greatly promote insensible perspiration. May not this arise principally from the strong attraction which subsists between wool and the watery vapour which is continually issuing from the human body? That it does not depend entirely on the warmth of that covering is clear; for the same degree of warmth, produced by wearing more clothing of a different kind, does not produce the same effect. The perspiration of the human body being absorbed by a covering of flannel, it is immediately distributed through the whole thickness of that substance, and by that means exposed, by a very large surface, to be carried off by the atmosphere; and the loss of this watery vapour, which the flannel sustains on the one side, by evaporation, being immediately restored from the other, in consequence of the strong attraction between the flannel and this vapour, the pores of the skin are disencumbered, and they are continually surrounded by a dry and salubrious atmosphere." He expresses his surprise, that the custom of wearing flannel next the skin should not have prevailed more universally. He is confident it would prevent a number of diseases: and he thinks there is no greater luxury, than the comfortable sensation which arises from wearing it, especially after one is a little accustomed to it. "It is a mistaken notion," says he, "that it is too warm a clothing for summer. I have worn it in the hottest climates, and at all seasons of the year; and never found the least inconvenience from it It is the warm bath of perspiration, confined by a linen shirt wet with sweat, which renders the summer heats of southern climates so insupportable; but flannel promotes perspiration, and favours its evaporation; and evaporation, as is well known, produces positive cold."

FLAT, in the sea-language. To flat in the fore-sail, is to hale it in by the sheet, as near the ship's side as possible; which is done, when a ship will not fall off from the wind.

Flats, in music, a kind of additional notes, which, together with sharps, serve to remedy the defects of musical instruments, wherein temperament is required.

FLATTING, in gilding, is the giving the work a light touch, in the places not burnished, with a pencil dipt in size, in which a little vermilion is sometimes mixt. This serves to preserve and prevent its flawing when handled. See Gilding.

FLATULENCY. See Medicine.

FLAX. See Linum.

Flax is an excellent commodity, and the cultivation of it a good piece of husbandry. It will thrive in any sound land, but that which has lain long fallow is best; which being well ploughed, and laid flat and even, the seeds must be sown in a warm season, about the middle or end of March, or at farthest the beginning of April; and if a wet season happen, weeding will be necessary. The best seed is that brought from the East country, which, though dear, yet easily repays the charge: this will last two or three crops, when it is advisable to renew the seeds again. Of the best seed, two bushels may serve for an acre; but more must be allowed of home-seed, because it grows smaller. When grown up it ought not to be gathered before it be fully ripe; for if pulled before the blossom falls, it hackles away almost to nothing; and, though in appearance very fine, yet it has no substance, and the yarn spun of it is weak and ouzy: it not only wastes in the washing, but the linen made of it grows extremely thin in the bleaching. The pluckers should be nimble, tie it up in handfuls, set them up till perfectly dry, and then house them. Flax pulled in the bloom proves whiter and stronger than if left standing till the seed is ripe; but then the seed will be lost.

Flax, *dressing of*. When flax has been watered, and twice swingled, it is then to be hackled in a much finer hackle than that used for hemp. Hold the strike of flax stiff in your hand, and break it very well upon the coarse hackle; saving the hurds to make harder cloth of. This done, the strike is to be passed through a finer hackle, and the hurds coming from thence saved for middling cloth, and the tare itself for the best linen.

But to dress flax for the finest use of all, after being handled as before, and laying three strikes together, plat them in a plat of three rows, as hard and close together as you can; joining one to the end of another, till you have platted as much as you think convenient: then begin another plat, and add as many several ones as you think will make a roll; afterwards wreathing them hard together, make up the roll; which done, put as many as you judge convenient into a hemp-trough, and beat them soundly, rather more than less than you do hemp. Next open and unplat them, dividing each strike very carefully from each other; and so strike it through the finest hackle of all, whereof there are three sorts. Great care must be taken to do this gently and lightly, lest what is hackled from thence should run to knots; for if preserved soft like cotton, it will make very good linen, each pound running at least two yards and an half. The tare itself, or finest flax, will make a strong and very fine holland, running at least five yards in the pound.

FLEA. See Pulex.

FLEAM, in surgery and farriery, an instrument for letting a horse blood. A case of fleams, as it is called by farriers, comprehends six sorts of instruments; two hooked ones, called drawers, and used for cleansing wounds; a pen-knife; a sharp-pointed lancet, for making incisions; and two fleams, one sharp and the other broad pointed. These last are somewhat like the point of a lancet, fixed in a flat handle, only no longer than is just necessary to open the vein.

FLEECE, the covering of wool shorn off the bodies of sheep. See Wool.

FLEECY *hosiery*, a very useful kind of manufacture, of late invention, in which fine fleeces of wool are interwoven into a cotton piece of the common stocking texture: the nature of the manufacture is thus described: having in the common stocking frame twisted silk, cotton-yarn, &c. begin the work in the common way of making hosiery, and having worked one or more course or courses in the usul method, begin to add a coating thus: draw the frame over the arch, and then hang wool or jersey, raw or unspun, upon the beards of the needles, and slide the same off their beards upon their stems, till it comes exactly under the ribs of the sinkers; then sink the jacks and sinkers, and bring forward the frame, till the wool or jersey is drawn under the beards of the needles; and having done this, draw the frame over the arch, and place a thread of spun materials upon the needles, and proceed in finishing the course in the usual way of manufacturing hosiery with spun materials. Any thing manufactured in this way has, on the one side, the appearance of common hosiery, and on the other side the appearance of raw wool.

FLEET, commonly implies a company of ships of war, belonging to any prince or state: but sometimes it denotes any number of trading ships, employed in any particular branch of commerce.

In sailing, a fleet of men of war is usually divided into three squadrons; the admiral's, the vice-admiral's, and the rear-admiral's squadron; all which, being distinguished by their flags and pendants, are

to put themselves, and, as near as may be, to keep themselves in their customary places, *viz.* The admiral, with his squadron, to sail in the van, that so he may lead the way to all the rest in the day-time, by the sight of the flag in the main-top-mast-head; and in the night-time, by his lights or lanterns. The vice-admiral, and his squadron, is to sail in the centre, or middle, of the fleet; the rear-admiral, and the ships of his squadron, to bring up the rear. But sometimes other divisions are made, and those composed of the lighter ships, and best sailers, are placed as wings to the van, centre, and rear.

Merchant-fleets generally take their denomination from the place they are bound to, as the Turkey-fleet, East-India fleet, &c. These, in time of peace, go in fleets, for their mutual aid and assistance: in time of war, besides this security, they likewise procure convoys of men of war, either to escort them to the places whither they are bound, or only a part of the way, to a certain place or latitude, beyond which they are judged out of danger of privateers, &c. See CONVOY.

FLESH. See ANATOMY.

FLEXION, in anatomy, is applied to the motion by which the arm or any other member of the body is bent. It is also applied to the muscles, nerves, &c.

FLEXION, or *flexure of curves.* See FLEXURE.

FLEXOR, in anatomy, a name applied to several muscles, which are so called from their office, which is to bend the part to which they belong, in opposition to the extensors, which open or stretch them. See ANATOMY.

FLEXURE *of curves*, in the higher geometry, is used to signify that a curve is both concave and convex, with respect to a given right line or a fixed point.

FLIGHT, in law. On an indictment of treason, felony, or even petit larceny, if the jury find that the party fled for it, he shall forfeit his goods and chattels, though he is acquitted of the offence; but the jury seldom find the flight, it being thought too severe a punishment for that to which a man is prompted by his natural love of liberty.

FLINT. A semi-transparent hard stone, of the siliceous order, of a greyish, black, or yellowish colour, well known for its general utility in giving fire with the steel. It is commonly found in nodules, in beds of chalk or sand, and frequently exhibits indications of its having been in a soft state. Some specimens are hollow, and internally lined with siliceous crystals. By long exposure on the surface of the ground, they gradually become white on their upper surface first, and afterwards all over. This whiteness, in process of time, penetrates into the substance of the flint, forming a crust sometimes one-twentieth of an inch thick, which may be scraped with a knife. It has been said, that this is a conversion of flint into calcareous earth; but we know of no proof of the fact; and as this white matter does not appear to be affected by nitric acid, we are inclined to think that the flint is merely shattered by the weather, in a manner somewhat analogous to the effect of ignition and quenching in water, which renders it white and friable.

Weigleb found the common flint to contain 80 parts in the 100 silex, 18 alumina, and 2 lime. It is used in making glass and pottery.

A solution of siliceous earth, made by fusing flints with a large proportion of fixed alkali, and dissolving the mass in water, is called liquor of flints.

FLOAT *of a fishing line*, the cork or quill that floats or swims above water. See ANGLING.

FLOAT also signifies a certain quantity of timber bound together with rafters, athwart, and put into a river to be conveyed down the stream; and even, sometimes, to carry burdens down a river with the stream.

FLOAT *boards*, those boards fixed to water wheels of undershot mills, serving to receive the impulse of the stream, whereby the wheel is carried round. See MILL.

FLOATING *bodies*, are those which swim on the surface of a fluid, the most interesting of which are ships and vessels employed in war and commerce. It is known to every seaman, of what vast moment it is to ascertain the stability of such vessels, and the positions they assume when they float freely on the surface of the water. To be able to accomplish this, it is necessary to understand the principles on which that stability and these positions depend. A floating body is pressed downwards by its own weight in a vertical line passing through its centre of gravity; and it is supported by the upward pressure of a fluid, which acts in a vertical line that passes through the centre of gravity of the part which is under the water; and without a coincidence between these two lines, in such a manner as that both centres of gravity may be in the same

vertical line, the solid will turn on an axis, till it gains a position in which the equilibrium of floating will be permament. From this it is obviously necessary to find what proportion the part immersed bears to the whole, to do which the specific gravity of the floating body must be known; after which it must be found by geometrical method, in what positions the solid can be placed on the surface of the fluid, so that both centres of gravity may be in the same vertical line, when any given part of the solid is immersed under the surface. These things being determined, something is still wanting, for positions may be assumed in which the circumstances now mentioned concur, and yet the solid will assume some other position, wherein it will permanently float. However operose and difficult (says an able mechanic) the calculations necessary to determine the stability of nautical vessels may, in some cases, be, yet they all depend upon the four following simple and obvious theorems, accompanied with other well known stereometrical and statical principles.

Theorem 1. Every floating body displaces a quantity of the fluid in which it floats, equal to its own weight; and consequently, the specific gravity of the fluid will be to that of the floating body, as the magnitude of the whole is to that of the part immersed.

Theorem 2. Every floating body is impelled downward by its own essential power, acting in the direction of a vertical line passing through the centre of gravity of the whole; and is impelled upward by the re-action of the fluid which supports it, acting in the direction of a vertical line passing through the centre of gravity of the part immersed; therefore, unless these two lines are coincident, the floating body thus impelled must revolve round an axis, either in motion or at rest, until the equilibrium is restored.

Theorem 3. If by any power whatever a vessel be deflected from an upright position, the perpendicular distance between two vertical lines passing through the centres of gravity of the whole, and of the part immersed respectively, will be as the stability of the vessel, and which will be positive, nothing, or negative, according as the metacentre is above, coincident with, or below the centre of gravity of the vessel.

Theorem 4. The common centre of gravity of any system of bodies being given in position, if any one of these bodies be moved from one part of the system to another, the corresponding motion of the common centre of gravity, estimated in any given direction, will be to that of the aforesaid body, estimated in the same direction, as the weight of the body moved is to that of the whole system. From whence it is evident, that in order to ascertain the stability of any vessel, the position of the centres of gravity of the whole, and of that part immersed, must be determined; with which, and the dimensions of the vessel, the line of floatation, and angle of deflection, the stability or power either to right itself or overturn, may be found.

FLOOD, among seamen, is when the tide begins to come up, or the water begins to rise, then they call it young flood; after which it is a quarter flood, half flood, and high flood. See TIDE.

FLOOD *mark*, the mark which the sea makes on the shore, at flowing water, and the highest tide: it is also called high-water-mark.

FLOOR. The lower part of a mine is called the floor, and the upper the roof.

FLORENTINE *work*. When Italy, many years past, enjoyed a state of perfect tranquillity, and the minds of all ranks of the inhabitants were under the influence of religious enthusiasm, the different orders of religious, the priests, and the nobles, each endeavoured to excel the other in the splendid decorations of churches, altars, and shrines; the arts of the architect, the sculptor, and the painter, were exhausted, and the pious almost at a loss how to dispose of their riches in honour of their numerous patron-saints. Mosaic work had been invented many centuries, but some ingenious person, disdaining the comparative ease of that beautiful and expensive manner of imitating paintings, thought of Florentine work, which is performed by inserting fragments of precious stones in cement, so as to represent any subject usually treated by the pencil.

Keysler mentions a Carthusian monastery, situated between Milan and Pavia, of uncommon magnificence: " the greatest part of the altars in the church are adorned with elegant representations of birds, flowers, &c. in the Florentine manner, performed by the artful position of precious stones inlaid in the marble. The convent entertains two excellent artists, a father and son, to perform these elegant works. The son, Valieri Sac, is so eminent in these performances, that the greatest mistress of embroidery would

find it difficult to equal with her needle and silk, the variety of colours and shades which he expresses by sparks of agate, ruby, amethyst, cornelian, jasper, lapis-lazuli, and other precious stones. The high altar piece, together with the tables on each side, are entirely of this Florentine work."

The Fabrica Degli Uffici, erected at Florence by Cosmo I., was appropriated in part for the reception of various artists, who worked exclusively for the Grand Duke. "But among all the performances executed here," says Keysler, "that styled Florentine work is the most elegant; sparks of precious stones, and particles of elegant marble, are so disposed as to represent the objects of nature in a very beautiful and surprising manner; but works of this kind require a prodigious time to complete them. A flower-piece lately finished, about a foot and a half in length, and half a foot in breadth, employed the artist above eighteen months; and a piece of embossed work, about the size of a common sheet of paper, representing the adoration of the Eastern magi, and a group of angels in the air, has already been forty years in hand, and under the direction of several masters.

The late unhappy state of Italy, and the probability of still further changes, has been so fatally destructive of the arts, that Florentine work will not soon be encouraged; and there is little doubt this laborious art will be almost lost.

FLORIN is sometimes used for a coin, and sometimes for a money of account. See Coin.

FLORY, Flowry, or Fleury, in heraldry, a cross that has the flowers at the end circumflex and turning down, differing from the potence, inasmuch as the latter stretches out more like that which is called patee.

FLOTILLA, a name given to a number of ships which get before the rest in their return, and give information of the departure and cargo of the flota and galleons.

FLOUR, the meal of wheat-corn, finely ground and sifted. Flour, when carefully analyzed, is found to be composed, 1, of fecula, which is insoluble in cold water, but soluble in hot water; 2, of gluten; 3, of a saccharine matter, susceptible of the spirituous fermentation.

FLOWER, in botany. By this term, former botanists, as Ray and Tournefort, &c. evidently meant the petals, or beautiful coloured leaves of the plant, which generally adhere to the seed-bud, or rudiment of the fruit. Since the introduction of the sexual method, the petals have lost their importance, and are now only considered as a finer sort of cover, which is generally present, but not essentially necessary to the existence of a flower. A flower then, in modern botany, is as different in meaning from the same term in former writers, as from the vulgar acceptations of the word at this day. The petals, the calyx, nay, the threads or filaments of the stamina, may all be wanting, yet it is a flower still, provided the anthers, or male organ, and the stigma or summit of the style, the female organ, can be traced; and that either immediately in the neighbourhood of one another, as in most plants; on different parts of the same plant, as in the class Monoecia; or on different plants raised from the same seed, as in the class Dioecia. In this manner is to be understood the general principle with which the sexual method sets out, that every vegetable is furnished with flower and fruit. The essence of the flower, therefore, consists in the anthers and stigma, which constitute a flower, whether the covers, that is, the calyx and petals, are present or not.

Flower *de luce*. See Iris.

Flower *de lis*, or Flower *de luce*, in heraldry, a bearing representing the lily, called the queen of flowers, and the true hieroglyphic of royal majesty; but of late it is become more common, being borne in some coats one, in others three, in others five, and in some semée, or spread all over the escutcheon in great numbers.

Flowers, in chemistry, a term formerly applied to a variety of substances procured by sublimation, and were in the form of slightly cohering powder: hence, in all old books, we find mention made of the flowers of antimony, arsenic, zinc, and bismuth, which are the sublimed oxides of these metals, either pure, or combined with a small quantity of sulphur: we have also still in use, though not generally, the terms, flowers of sulphur, benzoin, &c.

FLUATES, in chemistry, salts, of which the Fluoric acid (which see) is the chief ingredient. Fluor spar, denominated fluate of lime, which is found in great plenty in many countries, and is very abundant in Derbyshire, where it obtains the name of Derbyshire spar, is the most important among the fluates. The chief properties of these salts are, 1. When sulphuric acid is poured upon them, they emit acrid vapours of fluoric acid, which corrode glass. 2. When heated, several of them phosphoresce. 3. They are not decomposed by heat, nor altered by combus-

tibles. They combine with silica by means of heat.

FLUENT, in fluxions, the flowing quantity, or that which is continually either increasing or decreasing, whether line, surface, solid, &c. See FLUXION.

FLUID, in physiology, an appellation given to all bodies, whose particles easily yield to the least partial pressure or force impressed.

All fluids, except those in the form of air or gas, are incompressible in any considerable degree. The Academy del Cimento, from the following experiment, supposed water to be totally incompressible. A globe made of gold, which is less porous than any other metal, was completely filled with water, and then closed up; it was afterwards placed under a great compressive force, which pressed the fluid through the pores of the metal, and formed a dew all over its surface, before any indent could be made in the vessel. Now, as the surface of a sphere will contain a greater quantity than the same surface under any other form whatever, the academy supposed that the compressive power which was applied to the globe must either force the particles of the fluid into closer adhesion, or drive them through the sides of the vessel before any impression could be made on its surface; for although the latter effect took place, it furnishes no proof of the incompressibility of water, as the Florentines had no method of determining that the alteration of figure in their globe of gold occasioned such a diminution of its internal capacity, as was exactly equal to the quantity of water forced into its pores; but this experiment serves to shew the great minuteness of the particles of a fluid in penetrating the pores of gold, which is the densest of all metals. Mr. Canton brought the question of incompressibility to a more decisive determination. He procured a glass tube, of about two feet long, with a ball at one end, of an inch and a quarter in diameter: having filled the ball and part of the tube with mercury, and brought it to the heat of 50° of Fahrenheit's thermometer, he marked the place where the mercury stood, and then raised the mercury by heat to the top of the tube, and there sealed the tube hermetically; then, upon reducing the mercury to the same degree of heat as before, it stood in the tube $\frac{32}{100}$ of an inch higher than the mark. The same experiment was repeated with water, exhausted of air, instead of mercury, and the water stood in the tube $\frac{43}{100}$ above the mark. Now, since the weight of the atmosphere on the outside of the ball, without any counterbalance from within, will compress the ball, and equally raise both the mercury and water; it appears that the water expands $\frac{11}{100}$ of an inch more than the mercury, by removing the weight of the atmosphere. From this, and other experiments, he infers, that water is not only compressible, but elastic; and that it is more capable of compressibility in winter than in summer.

All fluids gravitate, or weigh, in proportion to their quantity of matter, not only in the open air, or in vacuo, but in their own elements. Although this law seems so consonant to reason, it has been supposed by ancient naturalists, who were ignorant of the equal and general pressure of all fluids, that the component parts, or the particles of the same element, did not gravitate or rest on each other; so that the weight of a vessel of water balanced in air would be entirely lost, when the fluid was weighed in its own element. The following experiment seems to leave this question perfectly decided: take a common bottle, corked close, with some shot in the inside to make it sink, and fasten it to the end of a scale beam; then immerse the bottle in water, and balance the weight in the opposite scale; afterwards open the neck of the bottle, and let it fill with water, which will cause it to sink; then weigh the bottle again. Now it will be found that the weight of the water which is contained in the bottle is equal to the difference of the weights in the scale, when it is balanced in air; which sufficiently shews that the weight of the water is the same in both situations. As the particles of fluids possess weight as a common property of bodies, it seems reasonable, that they should possess the consequent power of gravitation which belongs to bodies in general. Therefore, supposing that the particles which compose fluids be equal, their gravitation must likewise be equal; so that in the descent of fluids, when the particles are stopped and supported, the gravitation being equal, one particle will not have more propensity than another to change its situation, and after the impelling force has subsided, the particles will remain at absolute rest.

From the gravity of fluids arises their pressure, which is always proportioned to the gravity. For if the particles of fluids have equal magnitude and weight, the gravity or pressure must be propor-

tional to the depth, and equal in every horizontal line of fluid; consequently, the pressure on the bottom of vessels is equal in every part. The pressure of fluids upwards is equal to the pressure downwards, at any given depth. For, suppose a column of water to consist of any given number of particles acting upon each other in a perpendicular direction, the first particle acts upon the second with its own weight only; and, as the second is stationary, or fixed by the surrounding particle, according to the third law of motion, that action and reaction are equal, it is evident that the action, or gravity, in the first is repelled in an equal degree by the reaction of the second; and in like manner the second acts on the third, with its own gravity added to that of the first; but still the reaction increases in an equivalent degree, and so on throughout the whole depth of the fluid.

The particles of a fluid, at the same depth, press each other equally in all directions. This appears to rise out of the very nature of fluids; for as the particles give way to every impressive force, if the pressure amongst themselves should be unequal, the fluid could never be at rest, which is contrary to experience; therefore, we conclude that the particles press each other equally, which keeps them in their own places. This principle applies to the whole of a fluid as well as a part. For if four or five glass tubes, of different forms, be immersed in water, when the corks in the ends are taken out, the water will flow through the various windings of the different tubes, and rise in all of them to the same height as it stands in the straight tube: therefore the drops of fluids must be equally pressed in all directions during their ascent through the various angles of the tube, otherwise the fluid could not rise to the same height in them all.

From the mutual pressure and equal action of the particles of fluids, the surface will be perfectly smooth and parallel to the horizon. If from any exterior cause the surface of water has some parts higher than the rest, these will sink down by the natural force of their own gravitation, and diffuse themselves into an even surface. See Hydrostatics.

Fluids, *motion of.* The motion of fluids, *viz.* their descent or rise below or above the common surface or level of the source or fountain, is caused either, 1. By the natural gravity or pressure of the fluid contained in the reservoir, or fountain; or, 2. By the pressure or weight of the air on the surface of the fluid in the reservoir, when it is at the same time either taken off or diminished on some part in aqueducts or pipes of conduit. 3. By the spring or elastic power of compressed or condensed air, as in the common water engine. 4. By the force of pistons, as in all kinds of forcing pumps, &c. 5. By the power of attraction, as in the case of tides, &c.

FLUIDITY. The state of bodies when their parts are very readily moveable in all directions with respect to each other. Many useful and curious properties arise out of this modification of matter, which form the basis of the mechanical science called hydrostatics, and are of considerable importance in chemistry. But the attention of the chemist is chiefly directed to the state of fluidity, as it may affect the component parts of bodies.

A solid body may be converted into a fluid by heat. The less the temperature at which this is effected, the more fusible the body is said to be.

All fluids, not excepting the fixed metals, appear, from various facts, to be disposed to assume the elastic form, and this the more readily the higher the temperature. When a fluid is heated to such a degree as that its elasticity is equal to the pressure of the air, its interior parts arise up with ebullition.

The capacity of a dense fluid for caloric is greater than that of the same body when solid, but less than when in the elastic state. If this were not the case, the assumption of the fluid and elastic state would be scarcely at all progressive, but effected in most cases instantly as to sense. See Caloric.

The state of dense fluidity appears to be more favourable to chemical combination than either the solid or elastic state. In the solid state, the cohesive attraction prevents the parts from obeying their chemical tendencies; and in the elastic state, the repulsion between the parts has, in a great measure, the same effects. Hence it has been considered, though too hastily, as a chemical axiom, that *corpora non agunt nisi fluida.*

FLUOR *spar*, the native fluate of lime. See the next article.

FLUORIC *acid*, in chemistry, is obtained from fluor spar, or, as it is technically called, fluate of lime. It has not yet been decomposed, unless it be among the grand discoveries of Mr. Davy, not yet announced to the world. We have at-

tended the lectures of this professor, and think, in one of them, he said he had decomposed the fluoric acid: for want, however, of any written document on the subject, we must content ourselves with a summary account of the properties of this acid, which were investigated with accuracy and precision by Scheele and Priestley. The spar was not distinguished from others of a similar appearance till about the year 1768, when Margraff attempted to decompose it by means of the sulphuric acid. He found that it consisted of a white sublimate, and a peculiar acid; the sublimate proved afterwards to be lime, and the acid being denominated fluoric acid, it is now called the fluate of lime. Margraff found, to his astonishment, that the glass retort in which the experiment had been made was corroded, and even pierced with holes.

Fluoric acid may be obtained by putting a quantity of the spar in powder into a retort, pouring over it an equal quantity of sulphuric acid, and then applying a gentle heat. A gas ensues, which may be received in the usual manner, in jars, standing over mercury. This gas is the fluoric acid, which may be obtained dissolved in water, by luting to the retort a receiver containing that fluid. The distillation is to be conducted with a very moderate heat, to allow the gas to condense, and to prevent the fluor itself from subliming.

Soon after the discovery of this acid, it was doubted whether it possessed those properties that rendered it different from all other acids. Scheele, however, who had already investigated the subject, instituted another set of experiments, which completely established the fact.

The properties of this acid are, that, as a gas, it is invisible, and elastic like air: but it will not maintain combustion, nor can animals breathe it without death. In smell it is pungent, something similar to muriatic acid. It is heavier than common air, and corrodes the skin. When water is admitted in contact with this gas, it absorbs it rapidly; and if the gas be obtained by means of glass vessels, it deposits at the same time a quantity of silica. Water absorbs a large portion of this gas, and in that state it is usually called fluoric acid by chemists. It is then heavier than water, has an acid taste, reddens vegetable blues, and has the property of not congealing till cooled down to 23°. The pure acid may be obtained again from the compound by means of heat. Fluoric acid gas does not act upon any of the metals; but liquid fluoric acid is capable of oxyding iron, zinc, copper, and arsenic. It does not act upon the precious metals, nor upon platina, mercury, lead, tin, antimony, cobalt. It combines with alkalies, earths, and metallic oxides, and, with them, forms salts denominated fluates, of which the true fluor, Derbyshire spar, or fluate of lime, consists of

Lime - - - - - - -	57
Fluoric acid - - - -	16
Water - - - - - -	27
	100

The most remarkable property is that already alluded to, *viz.* the facility with which it corrodes glass and siliceous bodies, especially when hot, and the ease with which it holds silica in solution, even when in a state of gas. This affinity for silica is so great, that the thickest glass vessels can withstand its action only a short time. The order of its affinities is,

Alumina	Potash
Ammonia	Silex
Barytes	Soda
Lime	Strontian.
Magnesia	

As fluoric acid produces an insoluble compound with lime, it may be employed to detect the presence of that earth when held in solution. Two or three drops only of the acid will cause a milky cloud or precipitate to appear, if any lime is present.

Fluoric acid has been applied to engraving or etching on glass, and was used, according to Beckman, nearly a century and a half ago for that purpose, by an artist at Nuremberg, who obtained it from digesting fluor spar in nitric acid. Since, however, the discoveries of Scheele and Priestley, it has been more generally used, and the art is performed by covering the glass with wax, and then that part where the figures are to appear is laid bare, and the whole is exposed for some time to the hot vapour of fluoric acid. This simple process is employed with great advantage in writing labels on glass vessels, and in graduating thermometers, &c. See Thomson's Chemistry.

FLUSTRA, in natural history, *horn-wrack*, a genus of worms, of the order Zoophyta. Animal a polype, proceeding from porous cells; stem fixed, foliaceous, membranaceous, consisting of numerous

rows of cells united together, and woven like a mat. About eighteen species have been described.

FLUTE, an instrument of music, the simplest of all those of the wind kind. It is played on by blowing it with the mouth, and the tones or notes are changed by stopping and opening the holes disposed for that purpose along its side. The ancient fistulæ, or flutes, were made of reeds, afterwards of wood, and last of metal; but how they were blown, whether as our flutes, or as hautboys, does not appear.

FLUTE, *German*, is an instrument entirely different from the common flute. It is not, like that, put into the mouth to be played, but the end is stopt with a tampion or plug; and the lower lip is applied to a hole about two inches and a half, or three inches, distant from the end. The instrument is usually about a foot and a half long; rather bigger at the upper end than the lower: and perforated with holes, besides that for the mouth, the lowest of which is stopped and opened by the little finger's pressing on a brass, or sometimes a silver key, like those in hautboys, bassoons, &c. Its sound is exceedingly sweet and agreeable; and serves as a treble in a concert.

FLUX, a general term made use of to denote any substance or mixture added to assist the fusion of minerals In the large way, limestone or fluor spar are used as fluxes; but in small assays, the method of the great operations is not always followed, though it would be very frequently of advantage to do so. The fluxes made use of in assays, or philosophical experiments, consist usually of alkalies, which render the earthy mixtures fusible, by converting them into glass; or else glass itself into powder.

Alkaline fluxes are either the crude flux, the white flux, or the black flux. Crude flux is a mixture of nitre and tartar, which is put into the crucible with the mineral intended to be fused. The detonation of the nitre with the inflammable matter of the tartar is of service in some operations; though generally it is attended with inconvenience, on account of the swelling of the materials, which may throw them out of the vessel, if proper care be not taken either to throw in only a little of the mixture at a time, or to provide a large vessel.

White flux is formed by projecting equal parts of a mixture of nitre and tartar, by moderate portions at a time, into an ignited crucible. In the detonation which ensues, the nitric acid is decomposed, and flies off with the tartarous acid, and the remainder consists of the potash in a state of considerable purity. This has been called fixed nitre.

Black flux differs from the preceding, in the proportion of its ingredients. In this the weight of the tartar is double that of the nitre; on which account the combustion is incomplete, and a considerable portion of the tartarous acid is decomposed by the mere heat, and leaves a quantity of coal behind, on which the black colour depends. It is used where metallic ores are intended to be reduced, and effects this purpose by combining with the oxygen of the oxide.

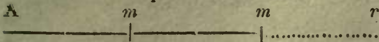
There is danger of loss in the treatment of sulphurous ores with alkaline fluxes: for, though much or the greater part of the sulphur may be dissipated by roasting, yet that which remains will form a sulphuret with the alkali, which is a very powerful solvent of metallic bodies. The advantage of M. Morveau's reducing flux seems to depend on its containing no uncombined alkali. It is made of eight parts of pulverized glass, one of calcined borax, and half a part of powder of charcoal. Care must be taken to use a glass which contains no lead. The white glasses contain in general a large proportion, and the green bottle glasses are not perhaps entirely free from it.

FLUX, in medicine, an extraordinary issue, or evacuation of some humours of the body. See MEDICINE.

FLUXION, in mathematics, denotes the velocity by which the fluents or flowing quantities increase or decrease; and may be considered as positive or negative, according as it relates to an increment or decrement.

The doctrine of fluxions, first invented by sir Isaac Newton, is of great use in the investigation of curves, and in the discovery of the quadratures of curvilinear spaces, and their ratifications. In this method, magnitudes are conceived to be generated by motion, and the velocity of the generating motion is the fluxion of the magnitude. Thus, the velocity of the point that describes a line is its fluxion, and measures its increase or decrease. When the motion of this point is uniform, its fluxion or velocity is constant, and may be measured by the space described in a given time; but when the motion varies, the fluxion of velocity at any given point is measured by the space that would be described in a given time, if the motion was to be continued uniformly from that term.

Thus, let the point m be conceived to



move from A, and generate the variable right line Am, by a motion any how regulated; and let its velocity, when it arrives at any proposed position or point R, be such as would, was it to continue uniform from that point, be sufficient to describe the line Rr, in the given time allotted for the fluxion, then will Rr be the fluxion of the variable line A m, in the term or point R

The fluxion of a plain surface is conceived in like manner, by supposing a given right line mn (Plate V. Miscel. fig. 8) to move parallel to itself, in the plane of the parallel and moveable lines AF and BG: for if, as above, Rr be taken to express the fluxion of the line A m, and the rectangle R r s S be completed; then that rectangle, being the space which would be uniformly described by the generating line m n, in the time that A m would be uniformly increased by m r, is therefore the fluxion of the generated rectangle B m, in that position.

If the length of the generating line $m\,n$ continually varies, the fluxion of the area will still be expounded by a rectangle under that line, and the fluxion of the absciss or base: for let the curvilinear space A n m (fig. 9,) be generated by the continual and parallel motion of the variable line m n; and let R r be the fluxion of the base or absciss A m, as before, then the rectangle R r s S will be the fluxion of the generated space A m n. Because, if the length and velocity of the generating line m n were to continue invariable from the position R S, the rectangle R r s S would then be uniformly generated with the very velocity wherewith it begins to be generated, or with which the space A m n is increased in that position.

FLUXIONS, *notation of*, of invariable quantities, or those which neither increase nor decrease, are represented by the first letters of the alphabet, as a, b, c, d, &c. and the variable or flowing quantities by the last letters, as v, w, x, y, z: thus, the diameter of a given circle may be denoted by a; and the sine of any arch thereof, considered as variable, by x. The fluxion of a quantity, represented by a single letter, is expressed by the same letter with a dot or full point over it: thus, the fluxion of x is represented by $\dot{x}$, and that of y by $\dot{y}$. And, because these fluxions are themselves often variable quantities, the velocities with which they either increase or decrease are the fluxions of the former fluxions, which may be called second fluxions, and are denoted by the same letters with two dots over them, and so on to the third, fourth, &c. fluxions. The whole doctrine of fluxions consists in solving the two following problems, *viz.* From the fluent, or variable flowing quantity given, to find the fluxion; which constitutes what is called the direct method of fluxions. 2. From the fluxion given, to find the fluent, or flowing quantity; which makes the inverse method of fluxions.

FLUXIONS, *direct method of*, the doctrine of this part of fluxions is comprised in these rules.

1. To find the fluxion of any simple variable quantity, the rule is to place a dot over it: thus, the fluxion of x is $\dot{x}$, and of y, $\dot{y}$ Again, the fluxion of the compound quantity $x+y$, is $\dot{x}+\dot{y}$; also the fluxion of $x-y$, is $\dot{x}-\dot{y}$

2 To find the fluxion of any given power of a variable quantity, multiply the fluxion of the root by the exponent of the power, and the product by that power of the same root, whose exponent is less by unity than the given exponent This rule is expressed more briefly, in algebraical characters, by $n x^{n-1} \dot{x}$ = the fluxion of x^n. Thus the fluxion of x^3 is $\dot{x} \times 3 \times x^2 = 3 x^2 \dot{x}$; and the fluxion of x^5 is $\dot{x} \times 5 \times x^4 = 5 x^4 x$. In the same manner the fluxion of $\overline{a+y}|^7$ is $7 \dot{y} \times \overline{a+y}|^6$; for the quantity a being constant, $\dot{y}$ is the true fluxion of the root $a+y$ Again, the fluxion of $\overline{a^2+z^2}|^{\frac{3}{2}}$ will be $\frac{3}{2} \times 2 z \dot{z} \times \overline{a^2+z^2}|^{\frac{1}{2}}$: for here x being put $= a^2+z^2$, we have $\dot{x} = 2 z \dot{z}$; and therefore $\frac{3}{2} x^{\frac{1}{2}} \dot{x}$ for the fluxion of $x^{\frac{3}{2}}$ (or $\overline{a^2+z^2}|^{\frac{3}{2}}$) is $= 3 z \dot{z} \sqrt{a^2+z^2}$

3 To find the fluxion of the product of several variable quantities, multiply the fluxion of each by the product of the rest of the quantities; and the sum of the products, thus arising, will be the fluxion sought. Thus, the fluxion of $x\,y$ is $\dot{x}\,y + \dot{y}\,x$; that of $x\,y\,z$ is $\dot{x}\,y\,z + \dot{y}\,x\,z + \dot{z}\,x\,y$; and that of $v\,x\,y\,z$ is $v\,x\,y\,z + \dot{x}\,v\,y\,z +$

$\dot{y} v x z + \dot{z} v x y$. Again, the fluxion of $\overline{a+x} \times \overline{b-y} = ab + bx - ay - xy$, is $b\dot{x} - a\dot{y} - \dot{x}y - \dot{y}x$.

4. To find the fluxion of a fraction, the rule is, from the fluxion of the numerator, multiplied by the denominator, subtract the fluxion of the denominator multiplied by the numerator, and divide the remainder by the square of the denominator. Thus, the fluxion of $\frac{x}{y}$ is $\frac{y\dot{x} - x\dot{y}}{y^2}$; that of $\frac{x}{x+y}$, is $\frac{\dot{x} \times \overline{x+y} - \overline{\dot{x}+\dot{y}} \times x}{\overline{x+y}^2} = \frac{y\dot{x} - x\dot{y}}{\overline{x+y}^2}$ and that of $\frac{x+y+z}{x+y}$, or $1 + \frac{z}{x+y}$, is $\frac{\dot{z} \times \overline{x+y} - \overline{\dot{x}+\dot{y}} \times z}{\overline{x+y}^2}$; and so of others.

In the examples hitherto given, each is resolved by its own particular rule; but in those that follow, the use of two or more of the above rules is requisite: thus (by rule 2 and 3) the fluxion of $x^2 y^2$ is found to be $2x^2 y\dot{y} + 2y^2 x\dot{x}$; that of $\frac{x^2}{y^2}$, is found (by rule 2 and 4) to be $\frac{2y^2 x\dot{x} - 2x^2 y\dot{y}}{y^4}$; and that of $\frac{x^2 y^2}{z}$, is (by rule 2, 3, and 4,) found to be $\frac{\overline{2x^2 y\dot{y} + 2y^2 x\dot{x}} \times z - x^2 y^2 \dot{z}}{z^2}$.

5. When the proposed quantity is affected by a coefficient, or constant multiplicator, the fluxion found as above must be multiplied by that coefficient or multiplicator: thus the fluxion of $5x^3$, is $15x^2\dot{x}$; for the fluxion of x^3 is $3x^2\dot{x}$, which multiplied by 5, gives $15x^2\dot{x}$. And, in the very same manner, the fluxion of ax^n will be $nax^{n-1}\dot{x}$.

Hence it appears, that whether the root be a simple or a compound quantity, the fluxion of any power of it is found by the following general Rule:

Multiply by the index, diminish the index by unity, and multiply by the fluxion of the root. Thus the fluxion of $z^8 = 8z^7\dot{z}$: the fluxion of $4x^6 = 24x^5\dot{x}$ and the fluxion of $\frac{3}{4}z^{\frac{4}{5}} = \frac{12}{20}z^{-\frac{1}{5}}\dot{z} = \frac{3\dot{z}}{5z^{\frac{1}{5}}}$.

Having explained the manner of determining the first fluxions of variable quantities, it is unnecessary in a work of this kind to enter upon the second, third, &c. fluxions, we shall therefore proceed to

FLUXIONS, *inverse method of*, or the manner of determining the fluents of given fluxions.

If what is already delivered, concerning the direct method, be duly considered, there will be no great difficulty in conceiving the reasons of the inverse method; though the difficulties that occur in this last part, upon another account, are indeed vastly great. It is an easy matter, or not impossible at most, to find the fluxion of any flowing quantity whatever; but, in the inverse method, the case is quite otherwise; for, as there is no method for deducing the fluent from the fluxion *a priori*, by a direct investigation, so it is impossible to lay down rules for any other forms of fluxions than those particular ones, that we know, from the direct method, belong to such and such kinds of flowing quantities; thus, for example, the fluent of $2x\dot{x}$ is known to be x^2; because, by the direct method, the fluxion of x^2 is found to be $2x\dot{x}$: but the fluent of $y\dot{x}$ is unknown, since no expression has been discovered that produces $y\dot{x}$ for its fluxion. Be this as it will, the following rules are those used by the best mathematicians, for finding the fluents of given fluxions.

1. To find the fluent of any simple fluxion, you need only write the letters without the dots over them: thus, the fluent of $\dot{x}$ is x, and that of $a\dot{x} + b\dot{y}$, is $ax + by$.

2. To assign the fluent of any power of a variable quantity, multiplied by the fluxion of the root; first divide by the fluxion of the root, add unity to the exponent of the power, and divide by the exponent so increased: for dividing the fluxion $nx^{n-1}\dot{x}$ by $\dot{x}$, it becomes nx^{n-1}; and adding 1 to the exponent $(n-1)$ we have nx^n; which divided by n, gives x^n, the true fluent of $nx^{n-1}\dot{x}$. Hence, by the same rule, the fluent of $3x^2\dot{x}$ will be $= x^3$; that of $2x^5\dot{x} = \frac{x^6}{3}$; that of $y^{\frac{1}{2}}\dot{y} = \frac{2}{3}y^{\frac{3}{2}}$; that of $ay^{\frac{5}{3}}\dot{y} = \frac{3ay^{\frac{8}{3}}}{8}$; and that of $y^{\frac{m}{n}}\dot{y} = \frac{y^{\frac{m}{n}+1}}{\frac{m+1}{n}} = \frac{ny^{\frac{m+n}{n}}}{m+n}$; that of $\frac{a\dot{x}}{x^n}$,

or $a\dot{x}x^{-n} = \frac{a x^{1-n}}{1-n}$; that of $\overline{a \times z}|^3 + \dot{z} = \frac{\overline{a+z}|^4}{4}$; and that of $\overline{a^m + z^m}|^n \times z^{m-1}\dot{z} = \frac{\overline{a^m + z^m}|^{n+1}}{m \times \overline{n+1}}$

In assigning the fluents of given fluxions, it ought to be considered whether the flowing quantity, found as above, requires the addition or subtraction of some constant quantity, to render it complete: thus, for instance, the fluent of $n x^{n-1}\dot{x}$ may be either represented by x^n or by $x \pm a$; for a being a constant quantity, the fluxion of $x^n \pm a$, as well as of x^n, is $n x_{n-1}\dot{x}$.

Hence it appears that the variable part of a fluent only can be assigned by the common method, the constant part being only assignable from the particular nature of the problem. Now to do this the best way is, to consider how much the variable part of the fluent, first found, differs from the truth, when the quantity which the whole fluent ought to express is equal to nothing; then that difference, added to, or subtracted from, the said variable part, as occasion requires, will give the fluent truly corrected. To make this plainer by an example or two, let $y = \overline{a+x}|^3 \times \dot{x}$. Here we first find $y = \frac{\overline{a+x}|^4}{4}$; but when $y = 0$, then $\frac{\overline{a+x}|^4}{4}$ becomes $= \frac{a^4}{4}$; since x, by hypothesis, is then $= 0$: therefore $\frac{\overline{a+x}|^4}{4}$ always exceeds y by $\frac{a^4}{4}$; and so the fluent, properly corrected, will be $y = \frac{\overline{a+x}|^4 - a^4}{4} = a^3 x + \frac{3a^2x^2}{2} + a x^3 + \frac{x^4}{4}$. Again, let $y = \overline{a^m + x^m}|^n \times x^{m-1}\dot{x}$: here we first have $y = \frac{\overline{a^m+x^m}|^{n+1}}{m \times \overline{n+1}}$ and making $y = 0$, the latter part of the equation becomes $\frac{\overline{a^m}|^{n+1}}{m \times \overline{n+1}} = \frac{a^{mn+m}}{m \times \overline{n+1}}$; whence the equation or fluent, properly corrected, is $y = \frac{\overline{a^m + x^m}|^{n+1} - a^{mn+m}}{m \times \overline{n+1}}$

Hitherto x and y are both supposed equal to nothing at the same time; which will not always be the case: thus, for instance, though the sine and tangent of an arch are both equal to nothing, when the arch itself is so; yet the secant is then equal to the radius. It will therefore be proper to add some examples, wherein the value of y is equal to nothing, when that of x is equal to any given quantity a. Thus, let the equation $\dot{y} = x^2\dot{x}$, be proposed; whereof the fluent first found is $y = \frac{x^3}{3}$; but when $y = 0$, then $\frac{x^3}{3} = \frac{a^3}{3}$, by the hypothesis; therefore the fluent, corrected, is $y = \frac{x^3 - a^3}{3}$. Again, suppose $\dot{y} = x^n\dot{x}$; then will $y = \frac{x^{n+1}}{n+1}$; which, corrected, becomes $y = \frac{a^{n+1} - x^{n+1}}{n+1}$. And lastly, if $\dot{y} = \overline{c^3 + bx^2}|^{\frac{1}{2}} \times x\dot{x}$; then, first, $y = \frac{\overline{c^3+bx^2}|^{\frac{3}{2}}}{3b}$: therefore the fluent, corrected, is $y = \frac{\overline{c^3+bx^2}|^{\frac{3}{2}} - \overline{c^3+ba^2}|^{\frac{3}{2}}}{3b}$

3. To find the fluents of such fluxionary expressions as involve two or more variable quantities, substitute, instead of such fluxion, its respective flowing quantity; and, adding all the terms together, divide the sum by the number of terms, and the quotient will be the fluent. Thus, the fluent of $\dot{x}y + \dot{y}x = \frac{xy + xy}{2} = \frac{2xy}{2} = xy$; and the fluent of $\dot{x}yz + \dot{y}xz + \dot{z}yx = \frac{xyz + xyz + xyz}{3} = \frac{3xyz}{3} = xyz$.

But it seldom happens that these kinds of fluxions, which involve two variable quantities in one term, and yet admit of known and perfect fluents, are to be met with in practice.

Having thus shown the manner of finding such fluents as can be truly exhibited in algebraic terms, it remains now to say something with regard to those other forms of expressions involving one variable quantity only; which yet are so affected by compound divisors and radical quantities, that their fluents cannot be accurately determined by any method whatsoever. The only method with regard to these, of which there are innume-

rable kinds, is to find their fluents by approximation, which, by the method of infinite series, may be done to any degree of exactness. See SERIES.

Thus, if it were proposed to find the fluent of $\frac{a\dot{x}}{a-x}$, it becomes necessary to throw the fluxion into an infinite series, by dividing $a\dot{x}$ by $a-x$: thus, $a\dot{x} \div \overline{a-x}$ $= \dot{x} + \frac{x\dot{x}}{a} + \frac{x^2\dot{x}}{a^2} + \frac{x^3\dot{x}}{a^3} + \frac{x^4\dot{x}}{a^4} +$, &c. Now the fluent of each term of this series may be found by the foregoing rules to be $x + \frac{x^2}{2a} + \frac{x^3}{3a^2} + \frac{x^4}{4a^3} + \frac{x^5}{5a^4}$ $+$, &c.

In order to show the usefulness of fluxions, we shall give an example or two, 1. Suppose it were required to divide any given right line A B into two such parts, A C, C B, that their products, or rectangles may be the greatest possible. Let A B $= a$, and let the part A C considered as variable (by the motion of C towards B) be denoted by x. Then B C being $= a - x$, we have A C $\times$ B C $=$ $a x - x x$, whose fluxion $a\dot{x} - 2x\dot{x}$ being put $= 0$, we get $a\dot{x} = 2x\dot{x}$; and, consequently, $x = \frac{1}{2}a$. Hence it appears that A C (or x) must be exactly one half of AB.

Ex. 2. To divide a given number a into two parts, x, y, so that $x^m y^n$ may be a maximum.

Since $x + y = a$, and $x^m y^n =$ max. the fluxion of each $= 0$, the former, because it is constant, and the latter, because it is a maximum: $\therefore \dot{x} + \dot{y} = 0$, and $m y^n x^{m-1}\dot{x} + n x^m y^{n-1}\dot{y} = 0$; hence, $\dot{x} =$ $-\dot{y}$, and $\dot{x} = -\frac{n x^m y^{n-1}\dot{y}}{m y^n x^{m-1}} = -\frac{n x\dot{y}}{m y}$; therefore $-\dot{y} = -\frac{n x\dot{y}}{m y}$; or $m y = n x$, and $m : n :: x : y$. Now $y = \frac{n x}{m}$; $\therefore x$ $+ \frac{n x}{m} = a$, consequently $x = \frac{m a}{m+n}$; and $y\left(=\frac{nx}{m}\right) = \frac{n a}{m+n}$.

If $m = n$, the two parts are equal.

Cor. Hence, to divide a quantity a into three parts, x, y, z, so that $x y z$ may be a max. the parts must be equal. For suppose x to remain constant, and y, z, to vary; the product y ., and consequently $x y z$, will be the greatest when $y = z$. Or if y remain constant, the product $x z$, and consequently $y x z$, will be greatest when $x = z$. Thus it appears that the parts must be equal. And in like manner it may be shown, that whatever be the number of parts, they will be equal.

Ex. 3. Given $x + y + z = a$, and $x y^2 z^3$ a maximum, to find x, y, z.

As x, y, z, must have some certain determinate values to answer these conditions, let us suppose such a value of y to remain constant, whilst x and z vary till they answer the conditions, and then $\dot{x} + \dot{z} = 0$ and $z^3\dot{x} + 3xz^2\dot{z} = 0$; hence, $\dot{x} = -\dot{z} = -\frac{3xz^2\dot{z}}{z^3} = -\frac{3x\dot{z}}{z}$, $\therefore z$ $= 3x$. Now let us suppose the value of z to remain constant, and x and y to vary, so as to satisfy the conditions; then $\dot{x} + \dot{y} = 0$, $y^2\dot{x} + 2xy\dot{y} = 0$; hence, $\dot{x} = -\dot{y} = -\frac{2xy\dot{y}}{y^2} = -\frac{2x\dot{y}}{y}$ $\therefore y = 2x$; substitute in the given equation, these values of y and z in terms of x, and $x + 2x + 3x = a$, or $6x = a$, hence, $x = \frac{1}{6}a$; $\therefore y = \frac{1}{3}a$; $z = \frac{1}{2}a$. In like manner, whatever be the number of unknown quantities, make any one of them variable with each of the rest, and the values of each in terms of that one quantity will be obtained; and by substituting the values of each in terms of that one, in the given equation, you will get the value of that quantity, and thence the values of the others.

Ex. 4. To inscribe the greatest parallelogram D F G I, in a given triangle A B C, fig. 10.

Draw B H perpendicular to A C; put A C $= a$, B H $= b$, B E $= x$, then E H $= b - x$; and by similar triangles, $b : a$ $:: x :$ D F $= \frac{ax}{b}$ hence, the area D F G I $= \frac{a x}{b} + \overline{b-x} =$ max. or $x \times \overline{b-x} =$ $b x - x^2 =$ max. $\therefore b\dot{x} - 2x\dot{x} = 0$; hence, $x = \frac{1}{2}b$; therefore E H $= \frac{1}{2}$B H.

Ex. 5. Let A B C represent a cone, A C the diameter of the base to in-

scribe in it the greatest cylinder D F G I, fig. 11.

Put $p = 78539$, &c. then since A C $= a$. B H $= b$. B E $= x \frac{p\, a^2 x^2}{b^2} =$ the area of the end D E F of the cylinder; hence, the content of the cylinder $= \frac{p\, a^2\, x^2}{b^2} \times \overline{b - x} =$ max. or $x^2 \times \overline{b - x} = b\, x^2 - x^3 =$ max. $\therefore 2\, b\, x\, \dot{x} - 3\, x^2\, \dot{x} = 0$; hence, $x = \frac{2}{3} b$; therefore E H $= \frac{1}{3}$ B H. See CYLINDER.

Ex. 6. To inscribe the greatest parallelogram D F G I in a given parabola A B C, fig. 11.

Put B H $= a$, $p =$ the parameter, $x =$ B E; then, by the property of the parabola, D E$^2 = p\, x$, $\therefore$ D E $= p^{\frac{1}{2}}\, x^{\frac{1}{2}}$, and D F $= 2\, p^{\frac{1}{2}}\, x^{\frac{1}{2}}$; hence, the area D F G I $= 2\, p^{\frac{1}{2}}\, x^{\frac{1}{2}} \times \overline{a - x} =$ max. or $x^{\frac{1}{2}} \times \overline{a - x} = a\, x^{\frac{1}{2}} - x^{\frac{3}{2}} =$ max. $\therefore \frac{1}{2}\, a\, x^{-\frac{1}{2}}\, \dot{x} - \frac{3}{2} x^{\frac{1}{2}} \dot{x} = 0$; hence, $\frac{a}{x^{\frac{1}{2}}} = 3\, x^{\frac{1}{2}}$, or $a = 3\, x$, $\therefore x = \frac{1}{3} a$; consequently E H $= \frac{2}{3}$ B. H.

Ex. 7. To cut the greatest parabola D E F from a given cone A B C, fig. 12.

Let A G C be that diameter of the base, which is perpendicular to D G F; now E G is parallel to A B; put A G $= a$, A B $= b$, C G $= x$, then A G $= a - x$: and by the property of the circle D G $= \sqrt{a\, x - x^2}$ $\therefore$ D F $= 2\sqrt{a\, x - x^2}$; also, by sim. $\triangle$s, $a : b :: x :$ G E $= \frac{b\, x}{a}$; hence, we have the area of the parabola $= \frac{2}{3} \times \frac{b\, x}{a} \times 2\sqrt{a\, x - x^2} =$ max. hence, $x\sqrt{a\, x - x^2} =$ max. or $x^2 \times \overline{a\, x - x^2} = a\, x^3 - x^4 =$ max. $\therefore 3\, a\, x^2\, \dot{x} - 4\, x^3\, \dot{x} = 0$, and $3\, a = 4\, x$, $\therefore x = \frac{3}{5}\, a$. See Simpson's and Vince's Fluxions.

FLY, in zoology, a large order of insects, or rather an indeterminate appellation, used to express a vast variety of insects belonging to different orders. Entomologists apply the term only to individuals of the genus Musca. See ENTOMOLOGY and MUSCA.

FLY, in mechanics, a cross with leaden weights at its ends, or rather a heavy wheel at right angles to the axis of a windlass, jack, or the like; by means of which the force of the power, whatever it be, is not only preserved, but equally distributed in all parts of the revolution of the machine.

The fly may be applied to several sorts of engines, whether moved by men, horses, wind, or water, or any other animate or inanimate power; and is of great use in those parts of an engine which have a quick circular motion, and where the power of the resistance acts unequally in the different parts of a revolution. This has made some people imagine, that the fly adds a new power; but though it may be truly said to facilitate the motion, by making it more uniform, yet upon the whole it causes a loss of power, and not an increase: for as the fly has no motion of its own it certainly requires a constant force to keep it in motion; not to mention the friction of the pivots of the axis, and the resistance of the air.

The reason, therefore, why the fly becomes useful in many engines, is not that it adds a new force to them, but because, in cases where the power acts unequally, it serves as a moderator, to make the motion of revolution almost every where equal: for as the fly has accumulated in itself a great degree of power, which it equally and gradually exerts, and as equally and gradually receives, it makes the motion in all parts of the revolution pretty nearly equal and uniform. The consequence of this is, that the engine becomes more easy and convenient to be acted on and moved by the impelling force; and this is the only benefit obtained by the fly.

The best form for a fly, is that of a heavy wheel or circle, of a fit size, as this will not only meet with less resistance from the air, but being continuous, and the weight every where equally distributed through the perimeter of the wheel, the motion will be more easy, uniform, and regular. In this form, the fly is most aptly applied to the perpendicular drill, which it likewise serves to keep upright by its centrifugal force: also to a wind-

lass or common winch, where the motion is quick; for in pulling upwards from the lower part, a person can exercise more power than in thrusting forward in the upper quarter, where, of course, part of his force would be lost, were it not accumulated and conserved in the equable motion of the fly. Hence, by this means, a man may work all day in drawing up a weight of 40*lb.* whereas 30*lb.* would create him more labour in a day without the fly.

In order to calculate the force of the fly, joined to the screw for stamping the image upon coins, let us suppose the two arms of the fly to be each fifteen inches long, measuring from the centre of the weight to the axis of motion, the weights to be 50 pounds each, and the diameter of the axis pressing upon the dye to be one inch. If every stroke be made in half a second, and the weights describe an half circumference, which, in this case, will be four feet, the velocity will at the instant of the stroke be at the rate of eight feet in a second, so that the momentum of it will be 800; but the arms of the fly being as levers, each fifteen inches long, whilst the semi-axis is only half an inch, we must increase this force 30 times, which will give 24,000; an immense force, equal to 100*lb.* falling 120 feet, or near two seconds in time; or to a body of 750*lb.* falling $16\frac{1}{12}$ feet, or one second in time. Some engines, for coining crown-pieces, used to have the arms of the fly five times as long, and the weights twice as heavy, so that the effect is ten times greater. See Coining.

Fly, in the sea language, that part of the mariner's compass on which the several winds or points are drawn. "Let fly the sheet," is a word of command to let loose the sheet, in case of a gust of wind, lest the ship should overset, or spend her top-sails and masts; which is prevented by letting the sheet go-amain, that it may hold no wind.

Fly *boat*, a large vessel with a double prow, carrying from four to six hundred tons.

FLYERS, in architecture, such stairs as go straight, and do not wind round; nor have the steps made tapering, but the fore and back part of each stair, and the ends, respectively, parallel to one another; so that if one flight do not carry you to your intended height, there is a broad half space, from whence you begin to fly again, with steps every where of the same length and breadth, as before.

FLYING, the progressive motion of a bird, or other winged animal, in the liquid air. The parts of birds chiefly concerned in flying are the wings, by which they are sustained or wafted along. The tail, Messeurs Willoughby, Ray, and many others, imagine to be principally employed in steering and turning the body in the air, as a rudder: but Borelli has put it beyond all doubt, that this is the least use of it, which is chiefly to assist the bird in its ascent and descent in the air; and to obviate the vacillations of the body and wings: for, as to turning to this or that side, it is performed by the wings, and inclinations of the body, and but very little by the help of the tail. The flying of a bird, in effect, is quite a different thing from the rowing of a vessel. Birds do not vibrate their wings towards the tail, as oars are struck towards the stern, but waft them downwards: nor does the tail of the bird cut the air at right angles, as the rudder does the water; but is disposed horizontally, and preserves the same situation what way so ever the bird turns.

In effect, as a vessel is turned about on its centre of gravity to the right, by a brisk application of the oars to the left, so a bird, in beating the air with its right wing alone, towards the tail, will turn its fore part to the left. Thus pigeons, changing their course to the left, would labour it with their right wing, keeping the other almost at rest. Birds of a long neck alter their course by the inclinations of their head and neck, which altering the course of gravity, the bird will proceed in a new direction.

The manner of flying is thus: the bird first bends his legs, and springs with a violent leap from the ground; then opens and expands the joints of his wings, so as to make a right line perpendicular to the sides of his body; thus the wings, with all the feathers therein, constitute one continued lamina. Being now raised a little above the horizon, and vibrating the wings with great force and velocity perpendicularly against the subject air, that fluid resists those successions, both from its natural inactivity and elasticity, by means of which the whole body of the bird is protruded. The resistance the air makes to the withdrawing of the wings, and consequently the progress of the bird, will be so much the greater, as the waft or stroke of the fan of the wing is longer: but as the force of the wing is continually diminished by this resistance, when the two forces come to be in equilibrio, the bird will remain suspended in the same place; for the bird only ascends

so long as the arch of air the wing describes makes a resistance equal to the excess of the specific gravity of the bird above the air. If the air, therefore, be so rare as to give way with the same velocity as it is struck withal, there will be no resistance, and consequently the bird can never mount. Birds never fly upwards in a perpendicular line, but always in a parabola. In a direct ascent, the natural and artificial tendency would oppose and destroy each other, so that the progress would be very slow. In a direct descent, they would aid one another, so that the fall would be too precipitate.

Flying, *artificial*, that attempted by men, by the assistance of mechanics. The art of flying has been attempted by several persons in all ages. The Leucadians, out of superstition, are reported to have had a custom of precipitating a man from a high cliff into the sea, first fixing feathers, variously expanded, round his body, in order to break his fall. Friar Bacon, who lived near five hundred years ago, not only affirms the art of flying possible, but assures us, that he himself knew how to make an engine, wherein a man, sitting, might be able to convey himself through the air, like a bird; and further adds, that there was then one who had tried it with success; but this method, which consisted of a couple of large, thin, hollow copper globes, exhausted of the air, and sustaining a person who sat thereon, Dr. Hook shows to be impracticable. The philosophers of K. Charles the second's reign were mightily busied about this art. Bishop Wilkins was so confident of success in it, that he says, he does not question but, in future ages, it will be as usual to hear a man call for his wings, when he is going a journey, as it is now to call for his boots.

The art of flying has, in some measure, been brought to bear in the construction and use of balloons. See Ærostation.

Flying *army*, a small body, under a lieutenant or major general, sent to harass the country, intercept convoys, prevent the enemy's incursions, cover its own garrisons, and keep the enemy in continual alarm.

Flying *bridge*. See Bridge.

Flying *fish*, a name given by the English writers to several species of fish, which, by means of their long fins, have a method of keeping themselves out of water some time. See Exocoetus, &c.

FOCUS, in geometry and conic sections, is applied to certain points in the parabola, ellipsis, and hyperbola, where the rays reflected from all parts of these curves concur and meet.

Foci *of an ellipsis*, are two points in the longest axis, on which as centres the figure is described. See Ellipsis.

If from the foci two right lines are drawn, meeting one another in the periphery of the ellipsis, their sum will be always equal to the longest axis; and therefore, when an ellipsis and its two axes are given, and the foci are required, you need only take half the longest axis in your compasses, and setting one foot in the end of the shorter, the other foot will cut the longer in the focus required.

Focus *of an hyperbola*, is that point in the axis, through which the latus rectum passes; from whence, if any two right lines are drawn, meeting in either of the opposite hyperbolas, their difference will be equal to the principal axis. See Hyperbola.

Focus *of a parabola*, a point in the axis within the figure, distant from the vertex one-fourth part of the latus rectum. See Parabola.

Focus, in optics, is the point wherein rays are collected, after they have undergone reflection or refraction. See Optics.

FODDER, any kind of meat for horses, or other cattle. In some places, hay and straw, mingled together, is peculiarly denominated fodder.

Fodder, in mining, a measure containing twenty-two hundred and an half weight, though in London but twenty hundred weight.

FŒTUS, in anatomy, a term applied to the offspring of the human subject, or of animals, during its residence in the uterus. The term of ovum is applied to the fœtus, with its membranes and placenta taken altogether. We shall consider, under this article, the anatomy of the membranes which cover the fœtus during its abode in the uterus; of the placenta, which forms the medium of connexion between the systems of the mother and child; and of the pregnant uterus itself, since the peculiarities, distinguishing its structure at this time, arise from the residence of the fœtus in its cavity. The following description applies to the uterus and its contents in the ninth month of gestation. The size of the organ differs much in different individuals; and this arises principally from varieties in the quantity of the liquor amnii. In shape it is oviform; the fundus answering to the largest extremity of the egg, and the cervix and os uteri to the small end. It

deviates from this regular figure from various accidental causes, as it adapts itself to the neighbouring parts, to the attitude of the body, and to the position of the contained child. Parts of the latter can often be distinguished in the living state. The small, or lower end of the uterus, is placed in the pelvis; this contains the greater part of the child's head, and fills up the cavity so completely as to press the bladder against the pubes, and the rectum against the sacrum. The body and fundus of the uterus, containing all the rest of the child and the placenta, is placed in the front of the abdomen, from the pelvis upwards to the epigastric region, so as to be under and before all the other bowels. It occupies the whole space from one hip-bone to the other.

The round ligaments, Fallopian tubes, and ovaria, necessarily undergo considerable change in their situation: they become closely connected to the uterus, as that body in its enlargement extends between the two layers of the broad ligaments. The ovaria are particularly distinguished after conception by containing a corpus luteum. This is a firm fleshy portion, distinguished by its yellowish gray colour from the rest of the ovary, and considered as a certain proof that conception has taken place. If there is one child, there is only one corpus luteum; if two children, two of these bodies, &c. The thickness of the pregnant uterus is from one to two-thirds of an inch. The arteries and veins of the uterus are wonderfully increased in size in the pregnant state, particularly opposite to the attachment of the placenta. This change seems to arise naturally from the important office which the vessels have to perform at this period; *viz.* the development and nutrition of the fœtus. Anatomists have disputed concerning the muscularity of the uterus; but Dr. Hunter describes the appearance of the muscular fibres, which are however very faint. The mouth of the uterus is closed, until the time of labour, by a viscid glutinous substance.

The contents of the pregnant uterus are, the secundines, liquor amnii, and the fœtus. The former line the uterus, and immediately cover the child; they form the chain of connexion and communication between the bodies of the mother and child, and carry on that wonderful influence upon which the life and health of the child depend. They are divided into navel-string, placenta, and membranes; and, as they are expelled from the uterus after the birth of the child, they are called the after-birth.

The navel-string is a cord about two feet long, made of three vessels twisted together, and fixed at one end to the child's navel, at the other to the placenta. Its vessels are an umbilical vein and two arteries: the latter carry blood from the child to the placenta, and the former brings it back again.

Placenta. This, with the membranes, makes a complete bag, lining the uterus, and containing the child. It is thick, fleshy, and exceedingly vascular. Its figure is round and flat, about an inch thick, and a span in breadth. The outer surface, which adheres to the womb, is rough, tender, and bloody; the inner is smooth, harder, and marked by the ramifications of the vessels proceeding from the umbilical cord, which is attached to this part. Its substance consists of two parts intimately blended; *viz.* an umbilical, or infantine, and an uterine portion. The former is a continuation of the umbilical vessels of the fœtus, the latter an efflorescence of the internal surface of the uterus. The fœtal portion, which is by far the largest part, is a regular ramification of the arteries and veins of the navel-string into smaller and smaller branches. No communication whatever has been discovered between these vessels and those of the uterus; so that the mode in which the fœtus derives its nourishment and growth must be completely hidden from us.

The uterine portion of the placenta covers its convex surface in the form of a thin membrane, and detaches innumerable fine processes into the substance of the part. It seems to be a portion of the decidua. It is connected into one mass with the umbilical portion, and the vessels of the uterus are continued into it, although they have no discoverable communication with the umbilical arteries and veins.

The membranes are three in number; amnion, chorion, and decidua.

The amnion is firm, thin, transparent, and possessing no visible vessels. It immediately includes the liquor amnii and child. The chorion lies outside of the amnion, and adheres to it; it is transparent, very thin and tender, and adheres externally to the decidua.

The decidua is an efflorescence of the internal coat of the uterus, produced after conception, in order to adapt the womb for the ovum which is to enter it. It is shed after every birth, or miscarriage, with the other membranes; and hence its name. It is thicker, but more delicate and tender, than the amnion or

chorion. It contains several blood vessels, which are best seen in recently discharged secundines. It adheres closely to the uterus on one side, and to the chorion on the other. The laceration of the vessels, which this membrane receives from the uterus, accounts for the hemorrhage which follows its separation. At the edge of the placenta it divides into two layers, which pass over the two surfaces of that organ, and form its uterine portion.

The liquor amnii is the fluid immediately surrounding the body of the child, and so called from the membrane enclosing it. Its usual quantity is about two pints. It is a clear, transparent fluid.

The child, while in the uterus, is naturally contracted into an oval form, adapted to the figure and circumstances of its habitation. The vertex of the head makes one end of the oval, and the nates the other. One side or edge of the oval is formed by the occiput, the back part of the neck, and the incurvated trunk; the other is made by the forehead and the mass of contracted and conglomerated limbs. The chin is close to the breast, the trunk bended forwards, the knees close to the fore parts of the hypochondria, the legs drawn to the back parts of the thighs, and the upper extremities contracted into the vacant space betwixt the forehead and knees. The more or less compact form of the child depends on the quantity of the liquor amnii; when that is small, the uterus moulds the child into various forms, and often produces deformities of the limbs. The head is placed downwards with respect to the mother, and the nates upwards.

The usual weight of the child at the time of birth is from five to eight pounds; of several thousands weighed at the British Lying-in Hospital, the largest weighed 11*lb.* 2*oz.* the smallest was above 4*lb.*

The head, upper part of the trunk, and upper extremities, are very large, when compared with the lower parts of the body. The surface of the skin is covered pretty generally with a white sebaceous matter.

Peculiarities in the Structure of the Fœtus.

These are on the whole numerous; but we shall briefly enumerate the most important only.

The first which claim our attention are, some points respecting the heart and large-blood-vessels; which we may suppose absolutely necessary to the life of the child, while it draws nourishment from the mother, and cannot enjoy respiration. As the fœtus in utero cannot breathe, the circulation of its blood through the lungs would be useless: hence that fluid can go from the right to the left side of the heart by means of an opening called the foramen ovale, and placed between the two auricles, and of a communicating canal from the pulmonary artery to the aorta, called ductus arteriosus. The umbilical arteries are continuations of the internal iliacs, taking the blood from the child to the placenta; from which it is brought back by the umbilical vein, and circulated through the liver.

The lungs are small and compact; and as they have not yet received air, they are specifically heavier than water. This is an important point, and is usually referred to in trials for child-murder, in order to determine whether the child was born alive or no. If the lungs sink in water, it is considered a still-born case; and if they float, the probable inference is, that the child has breathed, but it would be a very rash conclusion that it had, therefore, been murdered. Much caution and consideration of concomitant circumstances must be employed in making use of this proof. Putrefaction will disengage air that may make the lungs float.

The thymus gland, in the chest, is very large in the fœtus; it gradually shrinks after birth, until it entirely disappears. Its use is unknown.

The pupil of the eye is shut until the seventh or eighth month, by a thin pellicle called membrana pupillaris. As a general observation, the eye and ear are very perfect at the time of birth, and almost as large as they ever will be. (N. B. This does not apply to the external ear.)

The small intestines have no valvulæ conniventes. The large are filled with a dark green mucous and semifluid substance, called meconium. The liver is of an immense size, and fills two-thirds of the belly.

The renal capsules are very large, equal indeed to the kidnies themselves. Their use is unknown.

The testicle is placed originally in the abdomen, near the kidney; but it passes into the scrotum towards the latter periods of gestation. Sometimes it does not descend on one or both sides till after birth, and sometimes not even during life.

Of the Uterus and its Contents in the earlier Months of Pregnancy.

The conception at first is lodged entirely in the fundus uteri; and no part of it extends into the cervix; which, on the contrary, remains contracted and hard, and filled with a tough and firm jelly. The neck, however, is gradually distended, so that at last there is no distinction between it and the fundus.

The corpus luteum is larger and more vascular, and contains a cavity filled with fluid.

There is a small membraneous bag placed on the outer surface of the amnion, and connected to the navel-string, called the vesicula umbilicalis.

The chorion is at first covered all over with fine shaggy and floating processes, which are continuations of the umbilical vessels. By these it adheres to the decidua, and derives its nourishment and supply. These processes are the fœtal portion of the placenta at that time. As the ovum increases they disappear from the general surface of the chorion, become confined to one part, and form the fleshy part of the placenta.

The decidua is most manifest in the early state of conception, and is thickest at that time. It adheres to the uterus by numerous fine flocculent processes. It is formed by the uterus previously to the entrance of the ovum into its cavity; and is even formed in cases of extra uterine fœtus, where the ovum never enters the uterus.

The placenta does not exist in a very young ovum. The whole outer surface of the chorion is covered with shaggy vessels. In the course of a few weeks one half of the membrane becomes smooth, the remainder being covered as before. These vessels, at their floating extremities, are covered with decidua; and these parts, which at first are separable, gradually become intimately connected, and form a firm mass adhering to the uterus, which is the placenta.

The navel-string is not visible till towards the sixth or seventh week.

The fœtus is discernable about the fourth week after conception. In a particular instance, a very small fœtus was discernable, where, from peculiar circumstances, the conception was clearly ascertained to be twenty-two days old.

Towards the end of the second month it consists of two oval masses, the head and trunk; of which the former is bent forwards upon the chest; the eyes are very conspicuous, and form large black prominences; the mouth and tongue are discernible; the body forms a larger and longer oval than the head, with the lower part of the spine curved towards the belly: the upper extremities sprout out from each side of the chest; and the lower from the lower part of the trunk, being considerably smaller than the upper.

FOG, or Mist, a meteor consisting of gross vapours, floating near the surface of the earth. See Meteorology.

FOIL, among glass-grinders, a sheet of tin, with quicksilver or the like, laid on the backside of a looking-glass, to make it reflect.

Foil, among jewellers, a thin leaf of metal placed under a precious stone, in order to make it look transparent, and give it an agreeable different colour, either deep or pale. Thus, if you want a stone to be of a pale colour, put a foil of that colour under it; or if you would have it deep, lay a dark one under it.

FOLIATE, in the higher geometry, a name given by M. de Moivre to a curve of the second order, expressed by the equation $x^3+y^3=axy$; being a species of defective hyperbolas with one asymptote, and consisting of two infinite legs crossing one another, and forming a sort of leaf.

FOLIATING *of looking-glasses*, the spreading the plates over, after they are polished with quicksilver, &c. in order to reflect the image. It is performed thus: a thin blotting paper is spread on the table, and sprinkled with fine chalk: and then a fine lamina or leaf of tin, called foil, is laid over the paper; upon this mercury is poured, which is to be distributed equally over the leaf with a hare's foot, or cotton: over this is laid a clean paper, and over that the glass-plate, which is pressed down with the right hand, and the paper drawn gently out with the left: this being done, the plate is covered with a thicker paper, and loaden with a greater weight, that the superfluous mercury may be driven out, and the tin adhere more closely to the glass. When it is dried, the weight is removed, and the looking-glass is complete. Foliating of globe looking-glasses is done as follows: take five ounces of quicksilver, and one ounce of bismuth; of lead and tin half an ounce each. First put the lead and tin into fusion, then put in the bismuth, and when you perceive that in fusion too, let it stand till it is almost cold, and pour the qnicksilver into it:

after this, take the glass globe, which must be very clean, and the inside free from dust; make a paper funnel, which put into the hole of the globe, as near to the glass as you can, so that the amalgam, when you pour it in, may not splash, and cause the glass to be full of spots; pour it in gently, and move it about, so that the amalgam may touch every where. If you find the amalgam begin to be curdly and fixed, then hold it over a gentle fire, and it will easily flow again. And if you find the amalgam too thin, add a little more lead, tin, and bismuth, to it. The finer and clearer your globe is, the better will the looking-glass be.

FOLIO, in merchant's books, denotes a page, or rather both the right and left hand pages, these being expressed by the same figure, and corresponding to each other.

Folio, among printers and booksellers, the largest form of books, when each sheet is so printed, that it may be bound up in two leaves only. This form is only used in large works; but the quarto or octavo forms are much more handy.

FOLKMOTE, or Folcmote, according to Kennet, was the common-council of all the inhabitants of a city, town, or borough; though Spelman will have the folkmote to have been a sort of annual parliament or convention of the bishops, thanes, aldermen, and freemen, on every May-day. Dr. Brady, on the contrary, tells us, that it was an inferior court, held before the king's reeve, or his steward, every month, to do folk right.

FOMAHAUT, in astronomy, a star of the first magnitude in the constellation Aquarius.

FOMENTATION, in medicine, the bathing any part of the body with a convenient liquor; which is usually a decoction of herbs, water, wine, or milk; and the applying of bags stuffed with herbs and other ingredients, which is commonly called dry fomentation. Fomentations differ in little else from embrocations, but that they are mostly made with aqueous menstruums, are more extensive in their manner of application, and are assisted by actual heat and hot woollen cloths: add to this, that fomentations, when general, or applied to every part of the body, are called baths.

FONT, among ecclesiastical writers, a large basin, in which water is kept for the baptizing of infants, or other persons. It is so called, probably, because baptism was usually performed among the primitive christians at springs or fountains. In process of time the font came to be used, being placed at the lower end of the church, to intimate, perhaps, that baptism is the rite of admission into the Christian church.

Font. See Fount.

FONTANESIA, in botany, so named in honour of Mons. Desfontaines, a genus of the Diandria Monogynia class and order. Natural order of Sepiariæ. Jasmineæ, Jussieu. Essential character: calyx four-parted, inferior; petals two, two-parted; capsule membranaceous, not opening, two-celled; cells one-seeded. There is but one species.

FONTINALIS, in botany, a genus of the Cryptogamia Musci, or Mosses. Generic character: capsule oblong, with the mouth ciliate; opening with an acuminate lid; covered with a sessile, smooth, conical veil; included in a pitcher-shaped, imbricate perichætium. Only four species are known, and they are all natives of England: three of them are water mosses, and one grows upon trees. Professor Martin says, that several new species have been discovered by Swartz in the West Indies.

FOOD, implies whatever aliments are taken into the body to nourish it. See Dietetics.

FOOL, according to Mr. Locke, is a person who makes false conclusions from right principles; whereas a madman, on the contrary, draws right conclusions from wrong principles.

FOOT, *pes*, a part of the body of most animals, whereon they stand, walk, &c.

Animals are distinguished, with respect to the number of their feet, into bipedes, two-footed; such are men and birds: quadrupedes, four-footed; such are most land-animals: and multipedes, or many-footed; as insects. The reptile-kind, as serpents, &c. have no feet; the crab-kind have ten feet, but fishes have no feet at all; the spider, mites, &c. have eight; in some individuals of the genera scolopendra and julus, they amount to upwards of an hundred; but all true insects, as flies, grasshoppers, and butterflies, have six feet; animals destined to swim, and water-fowl, have their toes webbed together, as seals, ducks, &c.; the fore-feet of the mole, rabbit, &c. are wonderfully formed for digging and scratching up the earth, in order to make way for their body.

Foot. See Anatomy.

Foot, in the Latin and Greek poetry, a metre or measure, composed of a certain number of long and short syllables.

These feet are commonly reckoned twenty-eight, of which some are simple, as consisting of two or three syllables, and therefore called disyllabic or trisyllabic feet: others are compound, consisting of four syllables, and are therefore called tetrasyllabic feet.

FOOT is also a long measure, consisting of twelve inches. Geometricians divide the foot into ten digits, and the digit into ten lines. See DIGIT and LINE.

FOOT *square*, is the same measure both in breadth and length, containing 144 square or superficial inches.

FOOT *cubic*, or *solid*, is the same measure in all the three dimensions, length, breadth, and depth or thickness, containing 1728 cubic inches. The foot is of different lengths in different countries. The Paris royal foot exceeds the English by nine lines; the ancient Roman foot of the Capitol consisted of four palms, equal to $11\frac{7}{10}$ inches English; Rhineland or Leyden foot, by which the northern nations go, is to the Roman foot, as 950 to 1000. See MEASURE.

FOOT *geld*, or *Faut-geld*, in our old customs, an amercement laid upon those who live within the bounds of a forest, for not lawing or cutting out the ball of their dog's feet. To be free of a foot-geld, was a privilege to keep dogs, unlawed, within the bounds of a forest.

FOOT *level*, among artificers, an instrument that serves as a foot-rule, a square, and a level. See LEVEL.

FORAGE, in military affairs, implies hay, straw, and oats, for the subsistence of the army horses. It is divided into rations, of which one is a day's allowance for a horse, and contains 20 lb. of hay, 10 lb. of oats, and 5 lb. of straw. When cavalry is stationed in barracks in Great Britain, the number of rations of forage is, to field-officers four, supposing them to have four effective horses; to captains three; to staff-officers two; to quarter-masters, non-commissioned officers, and privates, each one. On foreign service, this article is governed by circumstances.

FORAMEN, in anatomy, a name given to several apertures, or perforations, in divers parts of the body; as, the foramen lachrymale, &c. See ANATOMY.

FORCE, in mechanics, denotes the cause of the change in the state of a body, when, being at rest, it begins to move, or has a motion which is either not uniform, or not direct. Mechanical forces may be reduced to two sorts, one of a body at rest, the other of a body in motion. See MECHANICS. The force of a body at rest is that which we conceive to be in a body lying still on a table, or hanging by a rope, or supported by a spring, and is called by the names of pressure, *vis mortua*, &c. the measure of this force being the weight with which the table is pressed, or the spring bent.

The force of a body in motion, called moving force, *vis motrix*, and *vis viva*, to distinguish it from the *vis mortua*, is allowed to be a power residing in that body so long as it continues its motion, by means of which it is able to remove obstacles lying in its way, to surmount any resistance, as tension, gravity, friction, &c. and which, in whole or in part, continues to accompany it so long as the body moves.

We have several curious, as well as useful observations, in Desagulier's "Experimental Philosophy," concerning the comparative forces of men and horses, and the best way of applying them. A horse draws with the greatest advantage when the line of direction is level with his breast; in such a situation, he is able to draw 200 lb. eight hours a-day, walking about two miles and a half an hour. And if the same horse is made to draw 240 lb. he can work but six hours a-day, and cannot go quite so fast. On a carriage, indeed, where a friction alone is to be overcome, a middling horse will draw 1000 lb. But the best way to try a horse's force is, by making him draw up out of a well, over a single pulley or roller; and, in such a case, one horse with another will draw 200 lb. as already observed. Five men are found to be equal in strength to one horse, and can with as much ease push round the horizontal beam of a mill, in a walk forty feet wide; whereas three men will do it in a walk only nineteen feet wide. The worst way of applying the force of a horse is, to make him carry or draw up hill; for if the hill be steep, three men will do more than a horse, each man climbing up faster with a burden of 100 lb. weight, than a horse that is loaded with 300 lb.; a difference which is owing to the position of the parts of the human body being better adapted to climb than those of a horse. On the other hand, the best way of applying the force of a horse is in a horizontal direction, wherein a man can exert least force; thus, a man weighing 140 lb. and drawing a boat along by means of a rope coming over his shoulders, cannot draw above 27 lb. or exert above one-seventh part of the force of a

horse employed to the same purpose. The very best and most effectual posture in a man is that of rowing, in which he not only acts with more muscles at once, for overcoming the resistance, than in any other position; but as he pulls backward, the weight of his body assists by way of lever.

Force *accelerative*, or *Retardive Force*, is that which respects the velocity of the motion only, accelerating or retarding it; and it is denoted by the quotient of the motive force, divided by the mass or weight of the body. So, if m denote the motive force, and b the body or its weight, and f the accelerating or retarding force, then is f as $\frac{m}{b}$. Again, forces are either constant or variable. Constant forces are such as remain and act continually the same for some determinate time. Such, for example, is the force of gravity, which acts constantly the same upon a body while it continues at the same distance from the centre of the earth, or from the centre of force, wherever that may be. In the case of a constant force F, acting upon a body b, for any time t, we have these following theorems; putting $f =$ the constant accelerating force $= F \div b$; $s =$ the velocity at the end of the time t; $v =$ the space passed over in that time, by the constant action of that force on the body: and $g = 16\frac{1}{12}$ feet, the space generated by gravity in 1 second, and calling the accelerating force of gravity 1; then is

$$s = \tfrac{1}{2}\,to = g f t^2 = \frac{v^2}{4gf};\ v = 2gft = \frac{2s}{t} = \surd\, 4gfs;\ t = \frac{v}{2gf}, = \frac{2s}{v} = \surd\frac{s}{gf}\ f = \frac{v}{2gt} = \frac{s}{gt^2} = \frac{v^2}{4gs}.$$

Forces *variable*, are such as are continually changing in their effect and intensity; such as the force of gravity at different distances from the centre of the earth, which decreases in proportion as the square of the distance increases. In variable forces, theorems similar to those above may be exhibited, by using the fluxions of quantities, and afterwards taking the fluents of the given fluxional equations. And herein consists one of the great excellencies of the Newtonian or modern analysis, by which we are enabled to manage and compute the effects of all kinds of variable forces, whether accelerating or retarding. Thus, using the same notation as above for constant forces, *viz.* f, the accelerating force at any instant; t, the time a body has been in motion by the action of the variable force; v, the velocity generated in that time; s, the space run over in that time; and $g = 16\frac{1}{12}$ feet; then is

$$\dot{s} = \frac{v\dot{v}}{2gf} = v\dot{t};\ \dot{v} = \frac{2gf\dot{s}}{v} = 2gf\dot{t};\ \dot{t} = \frac{\dot{s}}{v} = \frac{\dot{v}}{2gf};\ f = \frac{v\dot{v}}{2g\dot{s}} = \frac{\dot{v}}{2g\dot{t}}.$$

In these four theorems the force f, though variable, is supposed to be constant for the indefinitely small time $\dot{t}$; and they are to be used in all cases of variable forces, as the former ones in constant forces; *viz.* from the circumstances of the problem under consideration, deduce a general expression for the value of the force f, at any indefinite time t; then substitute it in one of these theorems, which shall be proper to the case in hand; and the equation thence resulting will determine the corresponding values of the other quantities in the problem. It is also to be observed, that the foregoing theorems equally hold good for the destruction of motion and velocity, by means of retarding or resisting forces, as for the generation of the same by means of accelerating forces.

FORCEPS, a pair of nippers, or pincers, for laying hold of and pulling out any thing forced into another body.

Forceps, in surgery, &c. a pair of scissars for cutting off, or dividing, the fleshy or membranous parts of the body, as occasion requires.

Forceps are commonly made of steel, but those of silver are much neater.

FORCER, or *forcing pump*, in mechanics, is a kind of pump in which there is a forcer or piston without a valve. See Pump.

Forcible entry and *detainer*. Forcible entry is a violent actual entry into a house or land, &c., or taking a distress of any person, armed, whether he offer violence or fear of hurt to any there, or furiously drive any out of the possession; if one enter another's house, without his consent, although the doors be open, this is a forcible entry, punishable by the law.

And an indictment will lie at common law for a forcible entry, though generally brought on the several statutes against forcible entry. The punishment for this offence is by fine and imprisonment.

Forcible *marriage*, if any person shall take away any woman having lands or

goods, or that is heir apparent to her ancestors, by force and against her will, and afterwards she be married to him, or to another by his procurement, or defiled, he, and also the procurers and receivers of such a woman, shall be adjudged principal felons. And by 39 Eliz. c. 9, the benefit of clergy is taken away from the principals, procurers, and accessaries before. And by 4 and 5 Phil. and Mary, c. 8, if any person shall take or convey away any unmarried woman, under the age of sixteen, (though not attended with force,) he shall be imprisoned two years, or fined, at the discretion of the court; and if he deflower her, or contract matrimony with her without the consent of her parent or guardian, he shall be imprisoned five years, or fined in like manner. And the marriage of any person under the age of twenty-one, by licence, without such consent, is void.

FORCING, among gardeners, signifies the making trees produce ripe fruit before their usual time. This is done by planting them in a hot-bed against a south-wall, and likewise defending them from the injuries of the weather by a glass frame. They should always be grown trees, as young ones are apt to be destroyed by this management. The glasses must be taken off at proper seasons, to admit the benefit of fresh air, and especially of gentle showers.

FORECASTLE, in naval affairs, a short deck placed in the fore-part of the ship above the upper deck; it is usually terminated both before and behind in vessels of war by a breast-work, the foremost part forming the top of the beak-head, and the hind part reaching to the after part of the fore chains. Forecastle men, are sailors stationed there, and are of the best kind as to experience and discipline.

Fore *foot*, in ship-building, a piece of timber which terminates the keel at the fore-end; it is connected by a scarf to the extremity of the keel, and the other end of it, which is incurvated upwards into a sort of knee, is attached to the lower end of the stem; it is also called a gripe.

Fore *foot*, in the sea-language, signifies one ship's lying, or sailing, across another's way: as if two ships being under sail, and in ken of one another, one of them lying in her course with her stem so much a-weather the other, that, holding on their several ways, neither of them altering their courses, the windward ship will run a-head of the other: then it is said, such a ship lies with other's fore foot.

Foreign *seamen*, serving two years on board British ships, whether of war, trade, or privateers, during the time of war, shall be deemed natural born subjects.

FORELORN *hope*, in the military art, signifies men detached from several regiments, or otherwise appointed, to make the first attack in day of battle, or, at a siege, to storm the counterscarp, mount the breach, or the like. They are so called, from the great danger they are unavoidably exposed to; but the word is old, and begins to be obsolete.

FOREMAST *of a ship*, a large, round piece of timber, placed in her fore-part, or fore-castle, and carrying the fore-sail and fore-top-sail yards. Its length is usually $\frac{8}{9}$ of the main-mast. And the fore-top-gallant mast is $\frac{1}{2}$ the length of the fore-top-mast. See Mast.

Foremast *men*, are those on board a ship that take in the top sails, fling the yards, furl the sails, bowse, trice, and take their turn at the helm, &c.

FORE *reach*, in the sea language, a ship is said to fore reach upon another, when, both sailing together, one sails better, or outgoeth the other.

FORESCHOKE, in our old authors, signifies the same with forsaken, and is particularly used in one of our statutes for lands or tenements seised by the lord for want of services performed by his tenant, and quietly held by such lord above a year and a day, without any due course of law taken by the tenant for recovery thereof; here he does in presumption of law disavow or forsake all the rights he has thereto, for which reason those lands shall be called foreschoke.

FORESKIN, in anatomy, the same with prepuce. See Prepuce.

FORE *staff*, or cross-staff, an instrument used at sea for taking the altitude of the sun, moon, or stars. It is called fore-staff, because the observer, in using it, turns his face towards the object; whereas, in using Davis's quadrant, the back of the observer is towards the object; and hence its denomination of back-staff.

FORESTALLING, is the buying or bargaining for any corn, cattle, or other merchandize, by the way, before it comes to any market or fair, to be sold; or by the way, as it comes from beyond the seas, or otherwise, towards any city, port, haven, or creek of this realm, to

the intent to sell the same again at a higher price.

At the common law, all endeavours to enhance the common price of any merchandize, and all practices which have an apparent tendency thereto, whether by spreading false rumours, or by purchasing things in a market before the accustomed hour, or by buying and selling again the same thing in the same market, or by any other such like devices, are highly criminal, and punishable by fine and imprisonment.

Several statutes have, from time to time, been made against these offences in general, which were repealed by 12 Geo. III. c. 71.

But though these offences are still punishable, upon indictment at the common law, by fine and imprisonment, the propriety of laws against forestalling has been lately very much doubted by some of the most eminent writers upon political economy, and they are now seldom enforced.

FORESTER, a sworn officer of the forest, appointed, by the king's letters patent, to walk the forest at all hours, to watch over the vert and venison; also to make attachments and true presentments of all trespasses committed within the forest.

Forests, are waste grounds belonging to the king, replenished with all manner of beasts of chase on venery, which are under the king's protection, for the sake of his royal recreation; and there are particular laws, privileges, courts and officers, belonging to the king's forests. The forest courts are, the courts of attachments, of regard, of swainmote, and of justice seat, &c. But as the forest laws have long ago ceased to be put in execution, we shall not enumerate them.

FORFEITURE, is a punishment, annexed by law to some illegal act or negligence in the owner of lands, tenements, or hereditaments, whereby he loses all his interest therein, and they go to the party injured, as a recompense for the wrong which either he alone, or the public together with him, have sustained. The offences which induce a forfeiture of lands and tenements are principally the following: treason, felony, misprision of treason, premunire, drawing a weapon on a judge, or striking any one in the presence of the king's court of justice. By the common law, all lands of inheritance, whereof the offender is seised in his own right, and also all rights of entry to lands in the hands of a wrong doer, are forfeited to the king on an attainder of high treason, although the lands are holden of another. Also upon an attainder of petit treason or felony, all lands of inheritance, whereof the offender is seised in his own right, as also rights of entry to lands in the hands of a wrong doer, are forfeited to the lord of whom they are immediately holden; for this, by the feudal law, was deemed a breach of the tenant's oath of fealty in the highest manner; his body, with which he had engaged to serve the lord, being forfeited to the king, and thereby his blood corrupted, so that no person could represent him; and all personal estates, whether they are in action or possession, which the party has, or is entitled to, in his own right, and not as executor or administrator to another, are liable to such forfeiture in the following cases:

1st. Upon a conviction of treason or felony. 2d. Upon a flight found before the coroner, on view of a dead body. 3d. Upon an acquittal on a capital felony, if the party be found to have fled. 4th. If any person indicted of petit larceny, and acquitted, be found to have fled for it, he forfeits his goods as in cases of grand larceny. 5th. Upon a presentment by the oaths of 12 men, that a person arrested for treason or felony fled from, or resisted those who had him in custody, and was killed by them in the pursuit or scuffle. 6th. If a felon waive, that is, leave any goods in his flight from those who either pursue him, or are apprehended by him so to do, he forfeits them, whether they are his own goods, or goods stolen by him; and at common law, if the owner did not pursue and appeal the felon, he lost the goods for ever: but by 21 Hen. VIII. c. 11. for encouraging the prosecution of felons, it is provided, that if the party came in as evidence on the indictment, and attaint the felon, he shall have a writ of restitution. 7th. If a man be felo de se, he forfeits his goods and chattels. 8th. A convict within clergy forfeits all his goods, though he be burnt in the hand; yet thereby he becomes capable of purchasing other goods. But, on burning in the hand, he ought to be immediately restored to the possession of his lands. The forfeiture upon an attainder of treason or felony shall have relation to the time of the offence, for the avoiding all subsequent alienation of the lands; but to the time of conviction, on *fugam fecit* found, &c. only as to

chattels, unless the party were killed in flying from, or resisting those who had arrested him: in which case, it is said that the forfeiture shall relate to the time of the offence.

FORFICULA, in natural history, the *earwig*, a genus of insects of the order Coleoptera. Antennæ setaceous; feelers unequal, filiform; shells half as long as the abdomen; wings folded up under the shells; tail armed with a forceps. There are eighteen species enumerated by Gmelin, two of which are natives of Europe, *viz.* F. auricularia, and F. minor. The former flies only by night, and can scarcely be made to expand its wings by day. The female deposits her eggs, which are rather large, white, and oval, under stones, in any damp situation, where they may be secure from too great heat or drought. From the eggs are hatched the larvæ, which are small, but possessing the general aspect of the parent animal, except being of a white colour. The parent insect, it is said, broods over her young, as the hen over her chickens. They change their skin at certain intervals during the earlier stages of their growth, and thus gradually acquire a darker colour, till at length the wing-sheaths and wings are formed, and the animals may be considered as perfect. The usual food of the earwig consists of decayed fruit: it will, however, if kept without food, attack and devour its own species. Gmelin seems to agree with the vulgar notion of its creeping into the ears of such as sleep in the open air; but Dr. Shaw regards it as an ancient, though generally received error. Others have, however, taken for granted, that such accidents may happen; and observe, that when this or any other insect falls into the ear, a little oil poured in will immediately kill it, after which it may be picked out, or discharged with a syringe of warm water.

FORGE, properly signifies a little furnace, wherein smiths and other artificers of iron or steel, &c. heat their metals red hot, in order to soften and render them more malleable and manageable on the anvil. An ordinary forge is nothing but a pair of bellows, the nozzle of which is directed upon a smooth area, on which coals are placed. The nozzle may also be directed to the bottom of any furnace, to excite the combustion of the coals placed there, by which a kind of forge is formed. In laboratories there is generally a small furnace consisting of a cylindrical piece, open at top, which has at its lower side a hole for receiving the nozzle of a double bellows. This kind of forge furnace is very convenient for fusions, as the operation is quickly performed, and with few coals. In its lower part, a little above the hole for receiving the nozzle of the bellows, may be placed an iron plate of the same diameter, supported upon two horizontal bars, and pierced near its circumference with four holes, diametrically opposite to each other. By this disposition the wind of the bellows, pushed forcibly under this plate, enters at these holes; and thus the heat of the fire is equally distributed, and the crucible in the furnace is equally surrounded by it. As the wind of bellows strongly and rapidly excites the action of the fire, a forge is very convenient when a great heat is required. The forge, or blast bellows, is used to fuse salts, metals, ores, &c. It is much used also in works which require strong heat, without much management; and chiefly in the smelting of ores, and fusion of metallic matters.

Forge, in the train of artillery, is generally called a travelling forge, and may not be improperly called a portable smith's shop: at this forge all manner of smith's work is made, and it can be used upon a march, as well as in camp.

Forge is also used for a large furnace, wherein iron ore, taken out of the mine, is melted down; or it is more properly applied to another kind of furnace, wherein the iron ore, melted down and separated in a former furnace, and then cast into sows and pigs, is heated and fused over again, and beaten afterwards with large hammers, and thus rendered more soft, pure, ductile, and fit for use.

FORGERY, is where a person counterfeits the signature of another, with intent to defraud; which by the law of England is made a capital felony. This law is now extended by statute to the counterfeiting of almost every written instrument which is either a security for money, or a public document or voucher upon which money may be received, or by which any one may be defrauded of money, by the act of imposing upon him such a false instrument. To enumerate the several statutes upon the subject would here be impossible. It is generally punished with the most rigorous severity. We shall add a few detached points with respect to the cases of forgery, which may be useful to explain cases of frequent occurrence.

Forgery may be committed by making a mark in the name of another person. It may be also committed in the name of a person who never had existence. Thus, indorsing a real bill of exchange with a

fictitious name is forgery, although the use of a fictitious name was not essential to the negotiation.

A receipt indorsed on a bill of exchange, in a fictitious name, is forgery, although such name does not purport to be the name of any particular person. If a person, who has for many years been known by a name which was not his own, and afterwards assume his real name, and in that name draw a bill of exchange, he will not be guilty of forgery, although such bill were drawn for fraudulent purposes.

The following statute is one of the most generally applicable to cases of forgery. If any person shall falsely make, forge, or counterfeit, or cause or procure to be falsely made, forged, or counterfeited, or willingly aid or assist in the false making or counterfeiting any deed, will, bond, writing obligatory, bill of exchange, promissory note for payment of money, acquittance, or receipt, either for money or goods, with intent to defraud any person, or shall utter or publish the same as true, knowing the same to be false, forged, or counterfeited, he shall be guilty of felony without benefit of clergy; but not to work corruption of blood, or disherison of heirs. 2 Geo. II. c. 25. From this, as well as other statutes, it will be seen, that not only the counterfeiting or forging false instruments, but the uttering, passing, or putting them off knowingly, is a capital felony; and in order to detect counterfeiters or forgers of bank notes, the being possessed only of such forged notes, knowing them to be forged, is now made by a late statute a transportable offence.

FORGING, in smithery, the beating or hammering iron on the anvil, after having first made it red hot in the forge, in order to extend it into various forms, and fashion it into works. See Forge.

Forging, or imitating stamps to defraud the revenue, is a capital forgery by the several stamp acts; and the receiving them knowingly is made single felony, punishable with seven years transportation. 12 Geo. III. c. 48. A person was lately executed for forging the ace of spades to a pack of cards.

FORM denotes the external appearance or surface of a body, or the disposition of its parts, as to the length, breadth, and thickness.

Form, among mechanics, for a sort of mould, whereon any thing is fashioned or wrought: as the hatter's form, the papermakers' form, &c.

Form, *printers'*, an assemblage of letters, words, and lines, ranged in order, and so disposed into pages by the compositor, from which, by means of ink and a press, the printed sheets are drawn. Every form is inclosed in an iron chase, wherein it is firmly locked by a number of pieces of wood; some long and narrow, and others of the form of wedges. There are two forms required for every sheet, one for each side; and each form consists of more or fewer pages, according to the size of the book.

Form *of a series*, in algebra, that affection of an undeterminate series, which arises from the different values of the indices of the known quantity. See Series.

FORMA *pauperis*, in law, is when any person has cause of suit, and is so poor that he cannot support the usual charges of suing at law or in equity. Upon his making oath that he is not worth five pounds, his debts being paid, and bringing a certificate from some barrister, that he has just cause of suit, the judge admits him to sue in *forma pauperis*, that is, without paying fees to counsellor, attornies, or clerk; and he shall have original writs and subpœnas gratis. And he shall, when plaintiff, be excused from costs, but shall suffer other punishment at the discretion of the judge. And it was formerly usual to give such paupers, if nonsuited, their election, either to be whipped, or pay the costs; though the practice is now disused.

It seems agreed, that a pauper may recover costs, though he pay none; for although the counsel and clerks are bound to give their labour to him, yet they are not bound to give it to his opponent.

FORMEDON, a real action to recover the right by the tenant in tail, or the reversioner, and which is called formedon, because the title or form of the don or gift is stated in the writ; there are three sorts, in the descender, remainder, and revertor. But these writs are now seldom brought, except in some special cases, where it cannot be avoided; the trial of titles by ejectment is now the usual method, and is done with much less trouble and expense.

FORMIC *acid*. It has long been known that ants contain a strong acid, which they occasionally emit; and which may be obtained from the ants, either by simple distillation or by infusion of them in boiling water, and subsequent distillation of as much of the water as can be brought over without burning the residue. After this, it may be purified by repeated rec-

tifications, or by boiling, to separate the impurities; or after rectification it may be concentrated by frost.

This has now lost its rank as a separate acid, and it has been shown by Fourcroy and Vauquelin to be a compound of the malic and acetic.

We have been informed, that it has been employed among quacks as a wonderful remedy for the tooth-ach, by applying it to the tooth with the points of the fore-finger and thumb.

FORMICA, in natural history, the *ant* or *emmet*, a genus of insects of the order Hymenoptera. Feelers four, unequal, with cylindrical articulations, placed at the tip of the lip, which is cylindrical and nearly membranaceous; antennæ filiform; a small erect scale between the thorax and abdomen; females and neuters armed with a concealed sting; males and females with wings, but to neuters there are no wings. This is a gregarious and very industrious family, consisting, as the generic character shows, of males, females, and neutrals. The last are well-known insects, who construct the nests or ant-hills, who labour with unremitting assiduity for the support of themselves and the males and females, and who guard with such ferocity the larvæ, or what are usually denominated ant's eggs. They wander about all day in search of food or materials for the nest, and assist each other in bringing home what is too heavy or large for such as have attempted it. They bring out of their nest, to expose to the warmth of the sun, the newly hatched larvæ, and feed them till they are able to provide for themselves. In the evening they consume together whatever has been collected during the day, and do not, as is commonly supposed, lay up any store for the winter. They are very coveteous of aphides, and are at the same time very careful not to injure them, feeding only on their honey-like excrement. In the conduct of the ant towards the aphis, a remarkable degree of intelligence is displayed. When the aphis does not readily give out this fluid, the ant applies its mandibles to its abdomen, and by a gentle pressure indicates its wants. Sometimes this tender and delicate creature is carried home by the ant in considerable numbers, and treated with the most marked attention; in return it supplies that industrious insect with a considerable quantity of food, and bears the same relation to it as that useful animal, the cow, does to man. This is exemplified in a yellowish ant not uncommon in Pennsylvania. (See Aphis.) The ant is eagerly sought after by the formica-leo, and various birds. Ants feed on animal and vegetable substances, devouring the smaller kinds of insects, caterpillars, &c. as well as fruits of different kinds. The largest of the European ants is the F. herculanea, or great wood-ant, of a chesnut colour, which is found in dry woods of fir, where it inhabits a large nest or hillock, composed of dry vegetable fragments, chiefly of fir-leaves: the nest is internally distributed into several paths or tubes, converged towards a central part, and opening externally; in the centre reside the larvæ, which are nursed by neutral ants. When full grown, they envelop themselves in oval white silken cases, in which they undergo their change into the chrysalis state, and at length emerge in their complete form. About seventy species have been described.

F. nigra is the common black ant of Europe. The great desire that ants have for animal food has been made use of by anatomists, who when they wish to obtain the skeleton of an animal too small or delicate to admit of being prepared in the usual way, dispose the animals in a proper position in a small box, with perforations in the lid, and deposit it in a large ant-hill, in consequence of which, after a certain time, the whole of the softer parts are eaten away by these insects, and the skeleton remains in its proper position.

F. rufa contains an acid which has undergone a chemical analysis, &c. See Formic *acid*.

FORMULA, or Formulary, a rule or model, or certain terms prescribed or decreed by authority, for the form and maner of an act, instrument, proceeding, or the like.

Formula, in church history and theology, signifies a profession of faith.

Formula, in medicine, imports the constitution of medicines, either simple or compound, both with respect to their prescription and consistence.

Formula, a theorem, or general rule, or expression, for resolving certain particular cases of some problem, &c. So $\frac{s}{2}+\frac{d}{2}$ is a general formula for the greater of two quantities, whose sum is s and difference d; and $\frac{s}{2}-\frac{d}{2}$ is the formula, or general value for the less quantity. Again, $\sqrt{dx-x^2}$ is the formula or general value of the ordinate to a circle, whose diameter is d and absciss x.

FORMULARY, a writing containing

the form of an oath, declaration, attestation, adjuration, &c. to be made on certain occasions.

FORNICATION, the act of incontinency in single persons; for if either party be married, it is adultery; the spiritual court hath the proper cognizance of this offence; but formerly the courts'-leet had power to inquire of and punish fornication and adultery; in which courts the king had a fine assessed on the offenders, as appears by the book of domesday.

FORSKOHLEA, in botany, so named in honour of Peter Forskahl, a Swede, a genus of the Octandria Tetragynia class and order. Natural order of Urticæ, Jussieu. Essential character: calyx four or five-leaved, longer than the corolla; petals eight or ten, spatulate; pericarpium none; seeds five, connected by wool. There are three species.

FORSTER (John Reinhold,) in biobraphy, an eminent naturalist and philologist, was born on the 22d of October, 1729, at Derschaw, in Polish Prussia, where his father was a burgomaster. He received very little education, except what he acquired himself by the natural strength of his own genius, till the year 1743, at which period he was placed for a year at the public school of Marienwerder; and when about fifteen he was sent to Berlin, where he was admitted into the gymnasium of Joachimsthal. Having a decided attachment to the learned languages, he made great progress under Mezelius and Heinsius; and even while at school, applied to the study of the Coptic. He applied also to several of the modern languages, and particularly the Polish, which he had an opportunity of speaking with his school-fellows, many of whom were Poles, and among whom, at that time, was a very extraordinary genius, Stanislaus von Siestrzencewitz, who, through ambitious views, afterwards embraced the Catholic religion, and, on account of his eloquence, was raised to the dignity of a bishop. Among his school-fellows also at this time were, Cochius, Resewitz, Irving, and the celebrated Pallas, now professor at Petersburgh.

In the year 1748, he was entered at the university of Halle; his inclination led him to the study of medicine; but his father was desirous that he should apply to jurisprudence; he, however, studied theology, and indulged his taste for the learned languages, among which he included the Oriental.

In the year 1751, he left the university, and repaired to Dantzic, where he soon distinguished himself by his sermons, in which he imitated the French rather than the Dutch manner, at that time the most prevalent. After being two years a candidate, he obtained a settlement, in 1753, at Nassenhuben, and in the month of February, next year, married his own cousin, Elizabeth Nikolai. While in this situation, he devoted great part of his leisure hours to philosophy, geography, and the mathematics, which were now his favourite pursuits; and he improved himself still farther in the knowledge of ancient and modern languages; but his income being small, and his family increasing, he had to struggle with difficulties, which induced him to accept an offer made to him by the Russian resident at Dantzic, of going to Russia, to superintend the new colonies at Saratow. At Petersburgh he gave so much satisfaction to the members of government, that count Orloff, who at that time enjoyed unlimited power, wrote to the resident at Dantzic, to thank him for having engaged a man of such great talents, and so agreeable to his wishes. But, whether Forster had shewn himself too warm a friend of the colonists, had expressed his sentiments with too much freedom, or given offence to Orloff in some other manner, he soon returned to Petersburgh without completing his engagement. On his return to the capital, he had advantageous offers made to him by the Academy of Sciences, and by that of Moscow, but he declined both. In the mean time, the congregation of Nassenhuben, whom he had left, insisted either on his returning or giving up the place. As he had still hopes that the Russian government would fulfil its promise, and make some provision for him, he preferred the latter; but his patience having been exhausted, his friends at Berlin, who had reason to expect hearing of his being on the banks of the Wolga, received letters from London, in the month of July, 1766, in which he stated, that he had left Russia in disgust, and had proceeded to England, with very little money, but with strong recommendations. After his arrival in London, he received from the Russian government a present of a hundred guineas; and by translating Kalm's travels, and Osbeck's voyage, he procured some additional funds towards the support of his family. He had an offer from lord Baltimore of being superintendant of his extensive property in America, but this he declined, and accepted the place of teacher of the French, German, and natural history, in the academy of Warrington. This

place, however, he left soon after, and returned to London, where he resided in very confined circumstances till the year 1772, when he was engaged to go out as naturalist with captain Cook, who was then ready to proceed on his second voyage round the world. Forster, at this time, was forty-three years of age, and was accompanied by his son George, then seventeen.

He returned to England in the year 1775, and soon after the university of Oxford conferred upon him the degree of doctor of laws. After his return, he published, conjointly with his son, a botanical work in Latin, containing the characters of a number of new genera of plants, which had been discovered by them in the course of their circumnavigation.

An account of the voyage having been published in English and German by young Forster, in which the father was supposed to have had a considerable share, though he had entered into an engagement not to publish any thing separately from the authorized narrative, they not only incurred the displeasure of government, but gave offence to the principal friends by whom they had been patronised. This work abounded with reflections injurious to the government in whose service they had been, and unfavourable to the navigators who had conducted the expedition. They were therefore treated with so much coolness, that they both determined to quit England.

Fortunately for Forster, after struggling some time with poverty and misfortunes in London, he was invited to Halle, in 1780, to be professor of natural history; he was also appointed inspector of the botanical garden; and as this office was connected with the faculty of medicine, he next year got the degree of doctor of medicine.

The loss of his son George, who died at an early period of life, made a deep impression on Forster, whose health was already in a declining state; and in the spring of the year 1798, his case was so desperate, that he expressed himself as a dying man in a letter to his friend Harsten, dated Halle, April 14. He did not long survive this letter, dying on the 9th of December, 1798, at the age of sixty-nine years and some months.

Forster is represented as a man of highly irritable and quarrelsome disposition, of which he is said to have given several instances during his voyage round the world; and which, added to a total want of prudence in common affairs, involved him, notwithstanding his talents, in perpetual difficulties.

The following character of him, by his friend the celebrated Kurt Sprengel, of Halle, exhibits him in a more favourable point of view: "To a knowledge of books, in all branches of science, seldom to be met with, he joined an uncommon fund of practical observations, of which he well knew how to avail himself. In natural history, in geography, both physical and moral, and in universal history, he was acquainted with a vast number of facts, of which he who draws his information from works only has not even a distant idea. This assertion is proved in the most striking manner by his 'Observations made in a Voyage round the World.' Of this book it may be said, that no traveller ever gathered so rich a treasure on his tour. What person of any education can read and study this work, which is unparalleled in its kind, without discovering in it that species of instructive and pleasing information which most interests man, as such? The uncommon pains which Forster took in his literary compositions, and his conscientious accuracy in historical disquisitions, are best evinced by his 'History of Voyages and Discoveries in the North,' and likewise by his excellent archæological dissertation 'On the Byssus of the Ancients.' Researches such as these were his favourite employment, in which he was greatly assisted by his intimate acquaintance with the classics. Forster had a predilection for the sublime in natural history, and aimed at general views, rather than detail. His favourite author therefore was Buffon, whom he used to recommend as a pattern of style, especially in his 'Epoques de la Nature,' his 'Description of the Horse, Camel, &c.' He had enjoyed the friendship of that distinguished naturalist, and he likewise kept up an uninterrupted epistolary intercourse with Linnæus, till the death of the latter. Without being a stickler for the forms and ceremonies of any particular persuasion, he adored the Eternal Author of All, who exists in the great temple of nature, and venerated his wisdom and goodness with an ardour and a heart-felt conviction, that, in his opinion, alone constituted the criterion of true religion. He held in utter contempt all those, who, to gratify their passions, or imitate the prevailing fashion, made a jest of the most sacred and reputable

feelings of mankind. His moral feelings were equally animated; he was attracted with irresistible force by whatever was true, good, or excellent. Great characters inspired him with an esteem which he sometimes expressed with incredible ardour."

His works, besides those above mentioned, are, for the most part, compilations and translations. He was the author also of several papers published in the "Philosophical Transactions," the "Memoirs of the Academy of Sciences" at Petersburgh, and those of other learned societies.

FORSTERA, in botany, a genus of the Gynandria Diandria class and order. Essential character: perianth double, outer inferior, three-leaved; inner superior, six-cleft; corolla tubular. There is but one species.

FORT, in the military art, a small fortified place, environed on all sides with a moat, rampart, and parapet. Its use is to secure some high ground or the passage of a river, to make good an advantageous post, to defend the lines and quarters of a siege, &c.

Forts are made of different figures and extents, according as the ground requires. Some are fortified with bastions, others with demi-bastions. Some again are in form of a square, others of a pentagon. A fort differs from a citadel, as this last is built to command some town.

FORTIFICATION. During the early ages, when the property of individuals was less valuable, or that, owing to the little progress made by mankind in the arts of despoliation and of seizing upon the possessions of their neighbours, the only fences in use were such as sufficed to restrain the depredations of wild beasts, and to prevent cattle, &c. from straying among the scattered patches of cultivation, or into the wilderness. In proportion, however, as commerce, or communication with others, and the pleasures of society, induced men to build towns and to congregate more generally, the various passions inducing to the commission of that variety of trespasses, which have even, within our own time, increased rapidly, rendered it prudent for each individual to secure his own habitation from clandestine or open assault, and caused the little communities, which every where began to appear, to adopt general means for personal defence, and for the curb of whatever encroachments might be attempted by others in their vicinity.

At a time when the great simplicity of manners gave a limit to the ambition even of the most aspiring, and when science was yet in the womb of time, we may reasonably conclude, that the means of control and of resistance, then in use, were neither costly, laborious, nor very effectual. The details furnished in scripture prove incontestibly, that even the circumvallations used at their date were inadequate to the purposes of security and duration. In fact, the events that shone conspicuous in those times were, with very few exceptions, pitched battles in the open plain, ambuscades, and treasonable conspiracies!

Nor do we find in the more recent histories of Rome, of Greece, of Asia, or of other parts then holding any rank in the military world, much to support the opinion of the ancients having knowledge of fortification. The few places that made any resistance, appear to have been principally maintained by the personal prowess of their defenders. Their walls were indeed, sometimes of great moment, as we see in the instance of Troy; which, if existing in the eighteenth century, would probably capitulate at the first summons.

It was not to be expected that, where the powers of demolition were insignificant, the means of resistance would be extended beyond the quantum absolutely necessary. The catapulta, the battering ram, the tower, and such devices, were opposed by heavy masses of stone or of other adequate materials, on which the besieged mounted, to repel the assault. The various contrivances whereby those machines received additional vigour, and the necessity that arose for opposing to their progress more resistance than could be accumulated immediately in their front, (of the tower in particular) first gave rise to the introduction of projections from the even line of the wall, whereby the besiegers could be annoyed laterally, as well as immediately front to front.

Still the engineer confined himself to small projections, generally semicircular, which, for the most part, appear to have been added to the old walls, impending like our modern balcony windows. In the sequel, these towers were built the same as the other parts of the circumvallation, and, like the modern bastion, rested on the terra firma. It however

seems doubtful, whether the former mode was not the best, considering every circumstance attendant upon the ancient mode of assault, and the nature of their weapons.

The invention of gunpowder does not appear to have made any important change for several years, nor indeed until heavy artillery formed a part of the assailant's means, as may be proved by an examination of the remaining castles, towers, keeps, &c. the dates may be traced beyond the middle of the fourteenth century. Such were the solidity and the hardness of many ancient buildings, that the stone shots, originally used, produced a very slight effect; nor was it until iron balls were brought into use, that the powers of cannon were, in any measure, ascertained.

That point being gained, the whole system of defence was necessarily made to conform to the destructive engines which now were added to the common practices of assault. The sword, buckler, lance, dart, javelin, sling, bow and arrow, lost their wonted estimation, and, dwindling into insignificance on the great scale, were reserved for individual contest, or for the lesser purposes of desultory warfare. The great object was, to construct such stupendous bulwarks, as might not only oppose the newly devised missiles, but, at the same time, support similar means of destroying the invading army.

Hence arose the formation of ramparts, and, gradually, the necessity for deep ditches, and various outworks ; whereby considerable delay and difficulty might be created.

The fortifications of the fifteenth century, although to a certain extent new-modelled, and made comformable to the necessity imposed by the invention and use of cannon, nevertheless did not display any ingenuity in regard to mutual defence. That great principle was little understood, and the minutiæ of the science remained, for a long time, miserably defective. Men of genus, at length, in part remedied the errors of the old school, and opened the way for that exactness of proportion, and for that systematic arrangement, which characterize the works of modern times. The impregnable fortresses to be seen in various parts of Europe cannot fail to transmit the names of their several engineers to posterity; unhappily, not unaccompanied by those of the traitors and poltroons, who, even since the commencement of the present century, have shamefully abandoned the posts of honour, and yielded to inferior powers.

The immense armies now constantly brought into the field, and the heavy trains of artillery by which they are, in almost all cases, attended, occasion not only an adequate preparation for resistance, but the necessity for establishing lines of communication, of depots, &c. all of which must be on the best construction for defence, containing safe lodgment for a sufficient garrison, together with ample and secure magazines for provisions and for stores. Hence the province of the engineer becomes peculiarly important ; it comprises various branches of information, and requires that readiness of computation, of discernment, and of appropriate resource, which rarely combine in the same individual. The merely planning in the closet, and the laying down on the soil, such defences as may perhaps be void of fault, so far as relates to mutual support, and to the great work of procrastination, will avail nothing, if the other essentials are neglected ; and even when they are not, the whole may be rendered abortive, and become contemptible, merely from a want of judgment in point of locality.

Fortification is generally considered under two heads, *i. e.* natural and artificial. The former relates entirely to those invaluable situations, which, being either completely inaccessible, or nearly so, require but few additions, and demand only such guards as may prevent surprise. For want of that precaution, some posts have been taken, which no army, however numerous and well provided, could have forced to capitulation. Perhaps, of all the instances that could be adduced in regard to so fortunate a position as should defy assault, the fortress of Ootradroog, situated in the dominions of the late Tippoo Saheb, sultan of the Mysore, may be justly considered as the most worthy of being cited. It stands on a plain, no hill or eminence of any consideration being within several miles. It is, in fact, insulated, and consists of a solid rock, rising, on a average, about eight hundred feet above the adjacent level ; its sides are nearly perpendicular throughout its whole circumference, which measures nearly a mile. The ascent into it is by stone steps, intermixed with occasional breaks for temporary ladders, the whole of which could be destroyed by the fall of a few large stones, always kept on the parapet for that purpose. Indeed, the interior is

lined with such, they being admirably suited to the defence of so peculiar a station. There is no want of cannon on the works, which are ample, and were formed under the direction of a French engineer; they have plenty of water; ample stores kept in immense excavations; and the most secure lodgment for a numerous garrison. Yet, so soon as the fall of Bangalore was ascertained, this important and absolutely impregnable fortress, to which, perhaps, there exists not a counterpart, surrendered to two battalions of Bengal sepoys.

It would be impossible to afford any instructions regarding those works which may be conjoined to natural defences, so as to render the whole complete; such must depend entirely on local circumstances, of which the skilful engineer will not fail to take advantage.

Artificial fortification applies to every kind of defence, whether regular or irregular, pure or mixed; and has been divided by the most celebrated engineers into two distinct kinds, *viz.* offensive and defensive. The former relates principally to the various works used in attacks and sieges; the latter appertains to the more general purpose of securing towns, forming depots, commanding choice situations, defiles, &c. protecting harbours, and, in general, tending more to self-preservation, and to control, than to the annoyance of others, or to the extension of dominion.

This important science is again subdivided into the permanent and the temporary: the former being with the view to endure the test of ages, while the latter is confined principally to operations in the field; and such works are, for the most part, abandoned, so soon as the occasion for their construction may have subsided.

Defensive fortification consists of three systems, each of which has its particular uses:

1. The little which is usually adopted in the construction of works, having four or five sides, or citadels, various small or detached posts, horn-works, crown-works, &c. where the exterior of the defences, that is, between the salient angles of the two bastions, does not exceed 350 yards.

2. The mean, which is of general use, and forms a very considerable portion of all regular fortifications, whose exterior sides of defence may be from 350 to about 400 yards.

3. The great, which is principally used where the exterior of the defences measures more than 380, and as far as 500 yards, or perhaps rather more; it is obvious, that such very extensive fronts, even in a hexagon, or figure of six sides, would enclose an immense area; consequently would require a moderate army to man the defences. Hence we generally find this system composing only part of the works; such as are on the borders of a lake, or of a marsh, or along the bank of a river; while the other sides are composed of the second or mean system.

Such are the leading features and applications of the three systems, as settled by the celebrated Vauban, and adopted by the most distinguished professors of our own time. Occasional deviations have, however, been made in several instances, with the approbation of pre-eminent engineers; but, for the most part, such have been with the view of conforming to local necessity, and of effecting a saving, either of materials, where they were scarce, or to disbursement, where parsimony was an object. Anomalies of this description are not to be considered as data whereby to be guided; but it may be proper to study the practical effects of all innovations, however much they may be abstracted from received theories; for the most happy inventions generally experience much opposition, often, indeed, illiberal contempt, while in their infancy. This should not deter the man of genus from ushering his suggestions to the notice of the world; for although his inefficient measures may appear wild and eccentric, or eventually be ignominiously decried by those invincibles, who, having learnt to work "by line and rule," neither will, nor can, correct their errors; yet there will never be wanting, in this enlightened age, persons who can both comprehend, and duly appreciate, the effusions of a vigorous and sensible innovator.

We now come to the description of the several defences, as regulated by Vauban, and others of acknowledged skill, premising, that many opinions have started, and other proportions been recommended by men of first rate talents, who have each their advocates. What is now offered may be deemed a concentration of their various hypotheses, so far as they could be assimilated into one general system: to give all would occupy volumes.

Fortifications may be considered as regular, when the enclosed area is of such a form, as can be inscribed in some regular

figure; such as a triangle, a rectangle, a circle, or an ellipsis: observing that such figure should, in a manner, fit the town, &c. it is intended to protect. It is usual to divide the perimeter, or whole outline of the figure, when it is either of the two latter forms, into as many faces, or portions, as may admit of suitable defences in either of the three systems already detailed. The number of faces must be regulated as well by the form, as by the extent of the figure. Small circles may be divided into five or six faces; moderately extensive ovals may have six also; while the more extensive circles and ovals will require an additional face or more, in order to reduce the exterior lines of defence within due bounds; so that every part of each face may be within musket shot of those parts whereby it is flanked, or defended. Whenever this fundamental principle is disregarded, the plan will be proportionally weaker, according to the undue prolongation of the faces, and the consequent deficiency of mutual support.

The several fronts of a fortification may be all dissimilar, both in their proportions and in their extent; as also in the number and construction of their several outworks; yet the whole cannot be termed irregular. Thus the two ends of a long oval may be constructed on the second, *i e.* the mean system; while each of the two long sides may be upon the third, or great system. One end may have a hornwork; the other a crown-work: the lateral faces being strengthened with ravelines, lunettes, tenailles, or other works, all these are evidently regular members of a perfect whole, and when duly combined according to the rules of art, form a complete and regular defence, founded on approved systems.

When the number of faces has been adjusted and laid down, it is proper to decide whether the works are to be planned outwards, or inwards, from the line laid down. In the former case much space is gained by keeping all clear within that line, which by this means becomes the interior side: in the latter instance the line becomes the exterior side, all the works being raised within it, which considerably diminishes the area within them. It is to be remembered, that in laying down the plan of a fortification, the several lines, describing the outer part of each rampart, exhibit the situation of a semicircular projection of masonry, called the cordon, which is, with few exceptions, made at the top of their respective facings of stone, brick, &c. called revetements. The line thus following the direction of the cordon, as it proceeds along the works, is called the principal.

A reference to fig. 1, Plate Fortification, will illustrate the foregoing description. The half of a hexagon, or polygon of six equal sides, is selected, as being the most appropriate to this occasion. The line, AD, is the diameter of the circle; which circle having been divided into six equal parts, each equal to the radius, or semidiameter, AE, or ED, gives the faces formed by the passage of the rays BE, and CE, through the points of equal division, B and C. Let us suppose the fortification to proceed inwards: in such case the lines AB, BC, CD, will be termed exterior sides, and all the principal will be formed within them; whereas, had it been intended to cover more ground, and to keep the whole of the area contained within the lines AB, BC, CD, and DC, clear, the principal would have been projected outwards, and the lines AB, BC, CD, would then have been termed the interior side. The former mode is in use when the exterior of the defences is first marked out, and has its separate mode of formation; and the latter is adopted, where the interior of the works is established by any pre-existing circumstances, such as fortifying an old town, &c.; and proceeds on a suitable plan of projection. The two modes correspond perfectly, giving the same angles and proportions; the former on a diminished, the latter on an extended scale.

The interior lines FG, GH, HI, form parallel faces with those on the exterior lines AB, BC, CD. If it were required to fortify outwards, they would be the bases of their several defences respectively, and the measurements would be taken from them, in lieu of from the exterior line. We shall proceed according to the latter mode, it being the most common and the most familiar.

To fortify inwards from an exterior line.—Let the exterior line BC be 180 toises, (each toise being one fathom, or six feet,) bisect it in *d*, and draw the perpendicular *d*8 equal to one sixth of the exterior line BC, namely, 30 toises. Now from B draw the line B *v*, passing through the point *n*; and from C draw the line C *u*, intersecting B *v* in *n*. Set off 50 toises from the points B and C, on their respective lines, which are called the lines of defence, giving B *t* and C *w* for the faces of the two bastions. With the opening *t w*, measure *t v* and *w u*, on the lines of defence, to determine their proper lengths, so as to give *u v* for the length and position of the curtain; next draw the lines *t v* and *w v*, ei-

ther curved or straight, for the flanks of the bastions. If they are to be curved, which are generally preferred, the points *t* and *w* will be the centres of equal circles, whereof the two flanks will be equal segments.

Proceed in the same manner with the other two fronts, AB and CD; you will thus complete two bastions, 3 and 4, and the halves of two more, 2 and 5. Next measure off 15 toises, and draw something less than quadrants, or quarters of circles, from the points B and C; the centres of those quadrants being exactly opposite thereto, place your scale so that you may draw lines from the ends of the quadrants towards the shoulders of the bastions, but draw no further than suffices to touch upon the perpendicular of 30 toises: thus your scale would give the direction, *l w*, but your line would stop a little below *d*. This being done in both directions, and throughout the three faces, will give the width of the ditch, and the interior lines or re-entering angles of the ravelines O, N, K. The body of the raveline is formed by measuring 10 toises on the face of each bastion, setting off from the shoulders *t w* towards the saliant, or projecting angles, (here called flanked angles,) B and C. An opening of the compasses equal to *u w*, (or to *i v*,) with the ten toises included, will give the distance of the saliant angle *o*, of the raveline N, from the centre S, of the curtain *u v*. The sides or faces of the ravelines, are determined by lines, drawn from the saliant angle to those points on the faces of the bastion 3 and 4, already set off at 10 toises each, from their respective shoulders *t* and *w*.

It should have been stated, that all angles projecting outward from the body of the place, are called saliant angles: for instance, *s*, B, *t*, of bastion 3, and *e*, *o*, *e*, of the raveline N: while such angles as point inwards towards the body of the place are designated re-entering angles; such as *t*, *u*, *w*, on the lines of defence of the centre face. When an angle re-enters at such a position in the outworks, that its apex or point cannot be seen, and consequently cannot be defended from the body of the place, it is called a dead angle. Such cannot easily take place, where the smallest attention is paid to the most ordinary rules; but, wherever found, should be exploded from the defences, either by cutting off a large part of the pinch, or narrowest part, and substituting a curtain, or by new modelling the defences in that part. It may be proper to observe in this place, that works intended for mutual defence should never exceed an angle of 120 degrees, nor be less than 60. The medium, *i. e.* 90, which forms a right angle, generally considered, is indisputably the best for the above purpose. Where batteries stand at such an opening, that their direct fire, that is immediately to their own front, is parallel with the front of the part they flank, it is called a razant, or grazing fire; but when the angle is less than 90, so that the direct fire would strike upon the face of the work to be defended, it is termed fishant, or plonging: both have their uses, but the latter is rarely adopted, except from necessity, because a direct fire, at right angles, may be made to plonge, by giving the cannon an inclination more parallel with the side of the embrasure, which being angular, allows a deviation of many degrees from the direct fire.

When two lines form a very acute angle with each other, they no longer are defences; for in case the enemy should carry either of them, he would be able to work its battery against the other line; and though the fire would be plonging, and that too at a great disadvantage, yet, as many shots would light within the embrasures, the parapet would speedily be destroyed. The revetement, or masonry, in the front of the line, so plonged, would not be much hurt, as it would turn off the shots.

Before we proceed farther, it is expedient that the reader should examine the line of the principal, following along A, *o*, S, *r*, *s*, B, *t*, *u*, *v*, *w*, C, *b*, *y*, *z*, *m*, D; in all which he will perceive, that every part is made to flank some other. The ravelines O, N, K, will be found to give great security to their several curtains, *s r*, *u v*, and *y z*; while at the same time they would enfilade whatever approaches might be made towards the saliant angles of the bastions. In examining these circumstances, all the other outworks must be exempted from consideration; our view must be confined to the manner in which the gates in the curtain are protected; the flanks of the bastions concealed from every part but the line of their direct fire; and the spaces opposite the saliant angles subjected to a heavy cross fire. The ravelines, themselves, stand at too wide an angle to absolutely flank each other, but they are capable of scouring the glacis reciprocally, and would, as before remarked, subject the besieger to a dangerous enfilade, or flanking fire, were he to proceed without due attention to their obnoxious positions. In works of more sides, where the angles of the bas-

tions are necessarily more obtuse, the ravelines are thrown more towards a right angle with each other, and afford mutual support, even in cases of assault.

The communications with the ravelines are effected by the aid of bridges, when wet ditches are in question, as may be seen in the third face, *y z*, where the bridge V is carried over from the curtain to the counterscarp, or outer face of the ditch, so as to afford access to the raveline K, in which is the intrenched redoubt L. The double lines, T, represent a channel of about fourteen feet broad, and about six or seven feet deep, made in all ditches that are at any time filled with water. These channels are called cunettes, or cuvettes; they are usually lined with masonry, and kept full, so as to prevent a surprise: when the water is allowed to fill the whole of the ditch, which should generally be to the depth of nine or ten feet, or at all events so as not to be fordable, the cunette proves a formidable obstacle.

The bridges have barriers at their outer ends, and towards their inner ends generally a draw-bridge, besides one that lifts immediately under the gateway, to which it gives additional strength. The very small compass allowed for the exhibiting of such figures as are indispensably necessary towards the right understanding of the subject, absolutely precludes the possibility of showing the dimensions of the ramparts, &c. and occasions the omission of many particulars in the plate, which must be therefore described. The foregoing impediment prevents us from showing the berm, which is a space, always left, between the cordon that runs along the inner brink, or scarp of the ditch, and the foot of the ramparts. Its use is to prevent the latter, when battered, from falling into the ditch; and it affords likewise a very good line of communication all round the works. The breadth of the berm is very uncertain; it should never be less than six feet, even where the works are scarped from the solid rock, and not subject to let fall much rubbish when battered. In the common mode of building ramparts with a revetement of masonry, the berm should be at least ten or twelve feet; and where only turf facing is used, or that the soil with which the rampart is filled, between the outer and inner faces of masonry, is of a loose nature, the berm should then be full twenty feet broad. The bulk of the rampart should, however, be considered also, whether it be much exposed or not; for on these points much will depend as to the probable quantity of battered rubbish to be sustained. There used to be a work, called the fausse-braye, carried all round the principal and the edge of the berm: its intention was to defend the ditch, and its fire was indeed highly destructive; but the facility with which it could be enfiladed, for it was necessarily low, evinced its inutility in general: the immense number of splinters falling from the rampart, immediately above, was another formidable objection. The fausse-braye is, therefore, out of repute; though in some fortifications, a substantial parapet supplies its place, generally of masonry, more for the purpose of stopping the rubbish of a battered rampart, than for the means of sheltering troops. Perhaps the strong hedge, adopted in many instances, may be preferable; to say the least, it is far cheaper, and stands to more advantage on the berm, than a heavy range of masonry.

The first draw-bridge generally connects with the body of the bridge passing over the ditch, and is drawn up by persons standing on the berm; while that draw-bridge, which rises close up against the gate, is so contrived as to bury itself, for at least its whole thickness, into the masonry; whereby its edges are secured from the grazing of shots ranging against the wall, and the possibility of wrenching the draw-bridge out of its place is sufficiently obviated. The gates usually close in the ordinary way of all large ones, that is, in two leaves, meeting in the centre; over them a portcullis is sometimes suspended horizontally; its hinges being close behind the gates when shut. This immense machine resembles a very large harrow, and lets down, much like the ports of a ship, until it hangs vertically, close at the back of the gates, and being secured with long iron stays, beams of wood passing like window bars into the wall, and other devices, it proves adequate to the repulsion of even a common sized petard. Some places have a succession of such gates and portcullices, one behind the other, which, added to the casemates being lined with defenders, renders it almost impossible to force the passages. When matters are driven to extremity, owing to the raveline being possessed by the enemy, and by the defences on the curtain and flanks being rased, the gateways are

then filled up with rubbish, either loose or in bags, &c. so that they are no longer passable.

The nakedness opposite the angle B, of bastion 3, is left purposely, to shew how easily a besieging army would effect a breach at that angle, provided no additional outworks were supplied; for, as yet, we are to consider the fortress to consist only of the principal and the ravelines. A suitable train of battering cannon brought to act upon the point B, while other batteries were employed to silence the faces of the adjacent ravelines O and N, would, in a very few days, effect a breach, and give the besiegers a command of the ditch, by establishing themselves in a lodgment on the crest of the glacis *g*, at the saliant point *q*; whence they would batter the flanks *o* S, and *w v*. Then, as nothing could oppose their passage over the ditch, which if wet would be passed by sap, (*i. e.* by filling up with fascines, &c.) the angle B would be carried by storm: for the matter would obviously rest on the numbers, and on the personal prowess of the contending forces. The issue of such affairs have been so various, that it would be presumption to say the besiegers must succeed; but if the breach be practicable, and the internal state of the bastion, as seen in No. 3, even though there should be an intrenchment of the gorge, *i. e.* from *r* to *u*, the chances would be in their favour, after the breach was gained. This mode of defence is perhaps the best in hollow bastions; that is, in such as are not solid, but have deep areas within them, level with the streets of the town, &c. (called the terre-pleine;) but in a solid bastion, some defences should be internally constructed while the breach is making; of this some idea may be formed by the flanked angle in bastion 4, where a rampart and ditch are made, to force those who may ascend the breach to quit the bastion. The gorge may also be fortified as in bastion 3, whereby much time may be gained, a matter often of the utmost importance, either from the expectation of succours, or to favour the evacuation of the fortress altogether.

In bastions No. 3 and 4, the flanks *t u*, and *w v*, are not only curved, but they are double, presenting, of course, two tiers of cannon, of which the upper stand on the bastion, while the lower are just below the level of the berm, whereof they constitute a part, and cannot be discovered beyond the crest of the glacis. These latter, therefore, cannot be battered from the approaches in the early stages of a siege: they lay, as it were, perdue, in reserve for the defence of the ditch. There are two little semi-circular projections at *t* and *w*, called orillons; these serve not only to cover the flanks *t u* and *w v* from enfilade, but each mounts a gun which cannot be perceived until half way over the bridge, and which serve to defend the gate when assaulted, as well as to take the assailants in flank, and partly in reverse, (*i. e.* from behind,) as they advance to the attack. They are especially useful when a tenaille, as seen at P, is constructed in the dry ditch before the curtain S *r*; for when those who were placed in the tenailles, which command the interior of the raveline O, and of the redoubt Q, may be attacked in flank, and be obliged to retreat into the principal, along the caponnaire P △, these guns pour in grape along the interior of the tenaille, when it is in the hands of the enemy, and enfilade so as to cause its abandonment.

The caponnaire is a passage made between two parapets, each having a long talus, or slope, outwards; as expressed by the small lines diverging from the path. It is commanded by (*i. e.* open to the fire) the flanks *o s*, and *s r*, and the centre of the curtain *s r*. Demi-caponnaires are common for the passage of troops from one outwork to another, as seen at *e e*, in the raveline N, where they serve to shelter the narrow defiles leading into the intrenchments *f f*, within the crown-work M. They have but one parapet, which is open to the fire of the faces B *t*, and *w c*, also to the oblique fire of the curtain between *u* and *v*. By their exterior slope they serve to flank the passage of the ditch of the raveline, in conjunction with the faces B *t*, and C *w*, which fire over them, and command the whole interior of the horn-work M.

Having established, by this exposition, the absolute necessity for adding exteriorly to the defence of the principal, we shall now proceed to give a general insight into the various modes of constructing the other outworks; all being so designated, which do not come within the principal or body of the place. The reader should understand, that every outwork, as it is placed more distant from the principal, must have a less elevation from the terre-pleine, or level of the area, on which the walls of the principal are founded. Thus we find, that a line drawn from

the foot of the glacis *g*, at Φ, opposite to the flanked angle of the bastion C, in the horn-work M, carried through the centre all the way up to E, which is the centre of the polygon, should graze the crests or inner summits of all the parapets standing in that line: this is called the defilement of the ramparts. By such a construction it must be obvious, that every added work is a screen to, but is commanded by, that within it: thus, the bastion C, in the crown-work M, is a screen to the raveline N, and that again to the curtain *u v*; while the intrenchments *f f*, correspond, in height with the flanks of the horn-work, so as to be under the command of the raveline, though they command all that portion of M which is in their front; and would continue to do so, until the beseigers should construct batteries in the gorges of the bastions *b*, C, *b*, or elsewhere, and render *f f* untenable.

The angle C, of bastion 4, is covered by the counterguard 7, which not only has that effect, but protects the adjacent tenaillon R, and can plonge upon the adjoining flank of the crown-work M. As a still further covering to the bastion 4, a fleche 9 is added, parallel to the counterguard 7, at the foot of its glacis, serving to render the attack more tedious and difficult, by compelling the beseigers to commence their approaches at a greater distance, where they are more generally subject to the fire from the bastions, &c. of the crown-work. The fleche (*i. e.* arrow-head,) should properly extend equally each way, having both faces alike, but that is not of any moment, and might have a second glacis; it is connected with the counter-guard, or with the crown-work, or with the tenaillon, by means of a sortie, or winding passage, cut through the glacis, or by a caponnier, as in the plate, intercepted with traverses, which will be duly explained when treating of the covert way.

The raveline K is defended within by the redoubt L, surrounded by a dry ditch. This redoubt should not be too high, because it would else serve to shelter the enemy in case they should succeed in silencing the faces of C 6, and *m* D, of the corresponding bastions 4 and 5. The small work S is a lunette, which must be carried, or silenced, before the raveline can be breached in that part; and, indeed before any lodgment can be made opposite to the flanked angle D, of the bastion 5. The lunette must be lower than the raveline, from which it properly derives its defilement, as will be hereafter explained.

The tenaillon R is a very important conjunctive to the raveline K; it, in fact, doubles its force on that side, and prolongs the battery of its other face; it flanks the counterguard, and its direct fire is a great protection to the demi-bastion *b*, on that side of the horn-work, as well as to the whole face of its raveline *a*; it commands the fleche; and being itself commanded by the raveline K, and by the face C 6, and the counterguard 7, cannot be occupied by an enemy while any of these three works remain in force.

With respect to the construction of the counterguard, lunette, and tenaillon, they are not upon any exact scale in proportion to the principal, as the raveline is, but though not perfectly arbitrary, their formations depend on some general rules, which should invariably be had in view. The counterguard is always placed on the counterscarp, its front immediately behind the glacis, and its rear, generally, being a continuation of the revetement of the counterscarp, so that the passage lays along its terre-pleine, or battery. This kind of work may be of any extent, that is, it may proceed from raveline to raveline without interruption; or it may break off where it enters a lunette, a tenaillon, or a redoubt; or it may be only formed of two parallels equal in length with the faces of the bastion. On account of the number of men required for the defence of extensive out-works, counterguards are advantageously made hollow, having casements covered with bomb-proofs, their parapets being solid masonry: their entrances, at each end, are secured by barriers and drawbridges; and their walls may, in places, be pierced with loop-holes, through which musquetry may be discharged against assailants.

Casemates are likewise made on each side of the posterns, or arched passages through the faces of ravelines; there are always drawbridges and barriers in such situations, as also at the cuts through the lunettes, &c. which lead through the covert way to the esplanade, and are called sorties. The necessity for casemates must, generally, depend on the quantity and distance of out-works from the body of the place: it should be a rule never to place an out-work so that it could be cut off, without receiving aid from some sufficiently strong and contiguous part. Were this neglected, the enemy would

not fail to surround such ill-judged detachments, and to a certainty carry them off during the night. Admitting this principle, the fleche 9 would be subject to the foregoing evil, if there were not a strong body of troops stationed in the counterguard 7, or the flank of the crown-work, from which detachments could be sent without delay.

Lunettes are generally constructed by producing their faces at about one half the length of the raveline which they flank at right angles; their own flanks are drawn perpendicular to the face of the bastion which commads them, generally falling about the middle of such face. See the lunette *s*, opposite the bastion D. Sometimes the lunette is separated, by a narrow fosse, from the body of the raveline; in other instances, its face joins that of the raveline; the fosse being arched over, and a battery placed on the arch, by which the ditch of the raveline is secured. The face of the lunette gives a direct fire towards the glacis, before the salient angle of the bastion 5.

Tenaillons, (signifying piercers, or claws,) are sometimes made on each side of a raveline, and even beyond them a small detached raveline, or a bonnet, is sometimes added. The rule for constructing a tenaillon is, to prolong the other face of the raveline, thereby to make its front, and to determine the length of that front, by a flank drawn perpendicular to the centre of the face of that bastion before which the tenaillon stands; as is seen in the tenaillon R, standing in front of the bastion 4, and covering the face of the raveline K.

Redoubts standing in ravelines, being intended as a resort for the troops driven from the defences of its faces, and requiring great strength of defenders, should invariably be casemated throughout, in the most substantial manner; they may not only mount batteries on their ramparts, which should command those of the ravelines wherein they are placed, but they may be pierced below with abundance of loop holes, and with embrazures for cannon, provided the ditch be of a sufficient depth and width to prevent assault, and that the interior of the raveline be, as it ought, perfectly level, and contain nothing to conceal the enemy: in each redoubt there should be a small expense magazine, and in every outwork one or more wells should be made, if practicable, of sufficient capacity to supply plenty of water.

Redoubts made to flank other works can have no fixed rule; they are generally placed to most advantage, and their fronts are always disposed towards those parts of the exterior which stand in need of such support. In some places, as at Q, they are made more to cover a weak point, than with any immediate view to protracting the assault: the want of a redoubt, or some other work, on the other side of the bastion O, serves to prove the utility of that at Q; it being evident, that could an enemy's battery be placed any where about C°, C°, that is, in a position to batter the bastion 3, the greater part of the defences of the principal would be subjected to mischief; and that, as the approaches should advance upon the glacis, the ravelines N, and O, would be in a measure cut off from all connection with the curtains S *r*, *u v*. We suppose the crown-work M not to exist.

We now come to speak of that crown-work; it is a limb of immense importance, and should be rendered as strong and efficient as possible. This kind of fortification is built on various accounts, *viz.* to occupy ground which, being left at the disposal of an enemy, might prove of considerable injury to the body of the place; to enclose buildings that could not be included within the principal; to defend a promontory, or a projection, covering a harbour; to prolong a line of works, and other causes which locality would suggest. When, however, a piece of ground, which stands higher than could be commanded from the works of the principal, is to be occupied, a crown-work would be improper: in such case, a citadel is advantageously made on the superior ground; observing, that in lieu of a raveline being at N, there should be a complete defensive face, appertaining to the citadel, commanding the works of the fortress, which, instead of presenting defences along the centre face B C, should rather lay open to the batteries of the citadel. These latter should command the whole interior of the polygon, and be well casemated throughout, for the safe lodgment of all the garrison, and for the safe keeping of provisions and stores for six months at least. The instances on record of citadels holding out for a long time should render their use more common, especially where the ground favours their command of all the other works.

Although we have in tracing the defilement of the ramparts, from the point Φ, to the centre of the polygon E, laid it down as a general rule, that the ascent of the works should assimilate to

that line; yet in such very spacious defences as crown-works sometimes are, (for their area is occasionally equal to a third of that within the interior line of the polygon,) some exceptions will take place; especially when the ravelines opposite to the faces of the crown-work are defended by still farther advanced out-works: then the angle of defilement would be so acute, from the terre-pleine, or horizon, as to cause scarce any difference between the heights of the ravelines and of the bastions of the crown-work; a matter of obvious impropriety. Hence it is often necessary to give the ramparts of a crown-work rather more height than the line of defilement might allow; raising the raveline and its entrenchments suitably, and making cavaliers, as instanced in the bastion C, of the crown-work, on the solid bastions 3 and 4, so as to command the whole of the crown-work completely. A moineau, or flat bastion, of similar height with the cavaliers, may be made in the centre of the curtain *u v*, for the same purpose.

Cavaliers are of singular use on many other occasions, to which their form should be accommodated: that in the bastion *c* of the crown-work is, from its shape, termed, a horseshoe; the flatness of its front is applicable to the situation it there holds, because it opposes a direct fire towards the point Φ; but its circular tendency gives its front a bias towards the inner parts of the faces of the ravelines, while its flanks present a direct fire into the ravelines themselves, and give an oblique fire into the opposite ditches, whereby the assault of breaches in the salient angles of the demibastions *b b*, would become very hazardous.

The proportions of a crown-work must depend greatly on the purposes for which it is erected, but, whatever be its object, the whole of its defences should be commanded by the works of the principal in so complete a manner, that no part whatever should offer an asylum to the enemy after carrying it; and consequently that none of its batteries should be able to play into any other of the defences. For the loss of so large a limb, and of the many serviceable cannon, platforms, &c. which in such case, are invariably and actively employed against the body of the place, is a very serious concern, and requires the utmost exertion to oppose even for a time. On this account it is highly necessary to have mines under all those parts which can prove serviceable in the smallest degree to the enemy, and to blow them up, whenever a favourable moment may present itself.

From what has been stated as to the purposes of crown works, it will be seen by reference to that laid down in the plate, that much attention is requisite to give them every defensive property, while on the other hand they should prove of little value to a successful assailant. The only work in our plan affected by such a circumstance would be, that the counterguard 7 would be untenable as a battery, though it might retain some small utility as a casement. But by mining all the inner part of the flank, which commands the counterguard, even that evil would be lessened: if, however, an enemy should be able to carry the raveline N, and to maintain his ground therein, notwithstanding the tremendous fires from the faces of the bastions 3 and 4, and from the curtain *u v*, (all of them direct) but little hope could remain of a successful resistance, and the counterguard would be, comparatively, no sacrifice. We, however, see from this, that a tenaille on the lines of defence, *t*, *u*, *w*, as shewn at P, between the bastions 2 and 3, must prove highly serviceable, especially if mounting such heavy metal as would destroy any works thrown up in the raveline N.

The entrenchments, *f f*, cut the ramparts of the flanks of the crown-work through all but the revetement, and they are carried as far forward as possible, so as barely to be flanked by a barbet battery in the salient angle of the raveline, that the bastions of the crown-work may be perfectly commanded by musquetry. The cavalier in C, is supposed to be mined and destroyed, else it would prove very disadvantageous to the defence of the raveline, which it would partly command.

We have already observed, that many out-works might be shewn, in addition to those given to the faces of the crown-work, such as lunettes, tenailles, tenaillons, fleches, advanced lunettes, redoubts, bonnets, &c. but we apprehend the reader will, from the foregoing details, and the plate to which they refer, be able to supply to his imagination the almost endless continuation of outworks, which the limits we are compelled to draw around this branch of science preclude us from enlarging upon.

The bonnet, mentioned in the preceding paragraph, is nothing more than an angle made parallel to a raveline, and not far removed from it, so that the faces of the latter command the faces of the bonnet. This out-work comes down to the lunettes, by which it is flanked.

We now have to treat of those important parts, the glacis, and the covert-way. The former is a gradual slope, commencing at a distance from the exterior of the out-works, seldom less than fifty yards, and when within five toises of the ditch, stops abruptly, occasioning a sudden fall, never less than seven, nor should it be more than nine feet. Here it is supported by a revetement, and is partly met by a banquette of turfed soil, which is raised high enough to come within four feet and a half of the crest, or highest part of the glacis. At the foot of the revetement, at such distance as may prevent an enemy jumping over, say from two to three feet off, a row of palisades is fixed; these are strong pales, nine feet in length, of which one-third is buried in the banquette, while the long horizontal rails, to which the palisades are firmly nailed, are at every ten feet morticed into square posts. The lower rails are one foot from the banquette, and the upper ones are just level with the crest of the glacis, so that the soldiers may fire through the top intervals between the pales, resting their pieces on the upper rail.

The primary defences are in the covert-way, but they are only for musquetry; as this part, owing to its laying very low, is subject to be enfiladed, and also because the saliant angles of the covert-way are sometimes abandoned from various causes, there are at every forty or fifty yards parapets, whose slopes point towards the exterior, or saliant angle of the covert-way, so that cannon shot may be stopped, and the defenders may make a stand, from time to time, behind these parapets, (which are called traverses,) until at last forced into the out-works for safety from the pursuing enemy. Each traverse is made the whole breadth of the covert-way, namely, 30 feet; their exterior ends would touch the palisades, were not little inlets made at right angles into the crest of the glacis, broad enough for two or three men to pass abreast. The traverses may be about six feet high within, and about five without; there is a banquette within which raises the defenders about a foot and a half, for them to stand upon, and to fire over the parapet, of which about ten feet is generally the thickness. Another method of passing the ends of the traverses is not uncommon, and is, perhaps, at least equally good as the foregoing; this is by making a serrated line of palisades, as seen in the plate, in which the small black projections from the line of the ditch represent the traverses, and the line bordering the glacis *g*, *g*, *g*, shews the line of the palisades; not unlike the teeth of a key-hole saw. The vacant spaces +, +, +, +, in the re-entering angles, are for the assembling of troops for the defence of the covert-way, and are called places of arms. In these, sometimes, small redoubts are thrown up. Places of arms are always near to some sortie from an out-work, so that the parties posted in them may be readily withdrawn, or be reinforced; in some instances, however, places of arms are made in the saliant angles of the covert-way; but they should then be in some measure entrenched, or protected, else they would be severely, and perhaps unnecessarily exposed, although the covert-way is so far above their heads.

The glacis is always made so as to give an inclined plane, corresponding with every change of direction in the line of the crest of the glacis; not, however, adverting to the small inlets, or serrated appearance, required for passing the ends of the traverses. This will be seen on reference to the plate, where every such inclined plane is particularized. Such a disposition of the glacis is indispensable; it gives the true direction of every part, as it respectively stands fronting to the line of palisades; so that the soldiers can scarcely fail to aim properly, if they fire straight before them, and rest their muskets on the upper rail. They thus graze the surface of the glacis, and consequently do great execution.

An extensive defence, called a horn-work, is sometimes substituted for a crown-work. The latter, as may be seen, is composed of a full bastion between two curtains, whose exterior sides are terminated by demi (or half) bastions; whereas the horn-work, in lieu of expanding as it recedes from the principal, contracts, and its front, (which should be parallel to that of the principal when it covers a curtain therein,) is formed only of a curtain, terminated by two demi-bastions. The out-works

beyond its ditch may be very numerous, though not so varied as those placed beyond a crown-work.

The object of both these defences, generally, is much the same; when a small diminishing tract is to be covered, the horn-work is proper, but when a round, or rather increasing, spot is to be enclosed, the crown-work should be preferred. The intrenchments within a horn-work are, however, the strongest, because they oppose a larger front against a smaller one; which is the reverse of what takes place in the crown-work, where the intrenchments, *f f*, are narrower than the front which can be opposed to them, between the flanked angles of the demi-bastions *b b*.

The explanation of fig. 2 next demands our attention: it is the profile of the principal, and of the proximate outwork. In this, not only the defilement, but the deviations from the terre-pleine, or line of the horizon, whether by superstructure or by excavation, are shewn.

A. represents the rampart of the principal, or body of the places of which the measurements may be in general terms, taken at the following computation. The height of the terre-pleine H, on which the cannon are mounted, 20 feet; the banquette I, on which the soldiers stand to fire their small arms, raised 3 feet above H; the point X, which is the crest of the parapet, being 4½ feet above the banquette I, and 7½ above the terre-pleine H. The upper part of the parapet is lower without than it is at the crest X. This declination, which is called the superior slope, is at the rate of one inch for every foot the parapet has of thickness, so as to allow the defenders to fire at an enemy almost close to the rampart, yet not to weaken the crest. K, shews a revetement of masonry, which should be five feet thick at the top of the rampart, not including the parapet, but measuring at the upper cordon O. The exterior slope of the revetement should be one sixth of its height, taken from the foot to the cordon. The foundation should project in proportion to the height, and to the nature of the soil. The interior slope of the parapet, and the banquette, are likewise bounded by a revetement in this figure, but such is not always the case; when it is, the ascent to the banquette is made by two or three steps, as here shewn. Nor are all parapets faced with masonry; the generality, indeed, are gazoned, or turfed, on account of the incalculable injury done by the splinters knocked off by such shots as graze upon masonry of any kind. In some instances, only half revetements are used, that is, only for the scarp, or face of the ditch, as seen at M under the cordon O; the whole exterior of the rampart itself being gazoned. The interior slope of the rampart, when made of masonry, as seen at P, where the counterscarp is carried up, or built upon, to form the interior slope of the counter-guard B, may be equal to only one-fifth of its whole height; but where masonry is not used, the interior slope, as at L, of the rampart A, should, if the soil be firm, be equal to the height of the rampart, which would give an angle of 45 degrees: when the soil is sandy, crumbly, or apt to give way, the interior slope should be equal to a height and a half, or even more, if circumstances should require. The continuation of the revetement M, above the cordon O, which is level with the terre-pleine of the berm N, is a firm parapet, made in lieu of the exploded fausse-braye, to prevent the ruins of the rampart A, when breached, from falling into the ditch C; of which the breadth is indefinite, though from 15 to 25 toises may be considered as the limits for works, according to the mean and great systems of Vauban. About the middle of the ditch, but generally rather more towards the counterscarp P, than towards the scarp M, is the cunette, or cuvette, about 15 feet broad, rivetted throughout, and from six to nine feet deep. It is always kept full of water, where that may be practicable; and, as it goes entirely around the body of the place, serves to prevent a surprise, to restrain from desertion, also from an improper access to spirituous liquors, and as a drain to the body of the ditch. In many instances, very fine supplies of fish are obtained from the cuvette. In some fortresses it is cut off from before the curtains by rows of palisades, standing on a shelving work, called a batardeau. Where it is continued before the curtains, there must be bridges of communication; and small temporary plank passages are made over in various parts, when occasion may require. All ditches should be sown with good grasses, that they may give a supply of that valuable commodity to such horses, &c. as may be kept in the fortress; and all gazoned facings, as well as the slopes of para-

pets, should be regularly mown for the same purpose.

The counterguard B is solid, as is also the rampart A; its terre-pleine H is considerably lower than that of A, which commands it, both by the cannon it mounts, and by its musquetry; the parapet being sloped so as to give a direct fire into it, when the firelocks are laid upon the slope at x. In this counterguard the interior of the parapet is not reveted; therefore the banquette I, ascended from the terre-pleine, H, by a slope of gazon. The parapet C, &c. are nearly the same dimensions as F on the rampart A, except that the rampart B is much lower than A. The exterior of B has a cordon, level with the terre-pleine H, but its parapet is faced with turf, which the cordon assists to support. If the counterguard B were not defended by other out-works in its front, it would have a glacis come close to it, leaving only a very small passage between its exterior and the palisades; here we suppose it to have a small dry ditch D, reveted both in the scarp and counterscarp, but without a berm, which is very rarely, if ever, allowed to an outwork.

The third figure affords a more general profile of the works, and gives some idea of the usual defilement of the outworks, B and C, from the body of the place A. D is the foot of the glacis, where it meets the terre-pleine, or level of the country, which we always suppose to be esplanaded, (that is, laid flat) and not affording any cover to the enemy for at least 1000 yards from the outworks. The glacis is usually made full 50 yards long, and of such an ascent as to give, on an average, about eight feet heigh at its crest. Supposing the angle of the raveline to be 25 yards within the crest of the glacis, the continuation of the ascent would strike the cordon of the rampart, C, at 12 feet from the level of the terre-pleine; this determines the height at which a cannon, standing on the terre-pleine of the raveline, C, would graze the glacis, while the slope of the embrazures would allow the guns to play into the covert way. It is observed, that, according to this construction, all the scarp, below the cordon, is completely hid from the enemy, and cannot be battered, so long as the crest of the glacis remains at its proper height. Hence partly arises the great difficulty of breaching the saliant angles of outworks.

Now let us estimate the redoubt, B, at 25 yards within the flanked angle of the bastion C. It is to be remarked, that this defence is made with the view to render the raveline untenable to an enemy; and that, for the preservation of its parapet, the rampart of the redoubt, B, should be a mere trifle above the level of that of the raveline, C. The faces of the contiguous bastions of the same front enfilade the faces of the raveline; but it is always requisite, that the fire from the curtain should, on emergency, (for the bastions may be silenced) contribute to drive the assailants from that part of the raveline which lays beyond the redoubt; at all events to clear its ramparts. Therefore we will state the terre-pleine of B at only one foot above that of C. This puts the redoubt completely out of the line of defilement, and, in fact, generates another, by allowing the curtain, A, to throw shot into C, without touching any part of B, as may be seen by following the line from the cordon of A to the terre-pleine of C. Hence B cannot be battered from the glacis.

But where it is necessary to produce the greatest accumulation of strength against any exterior point, it is often found proper to raise every part of the interior defences, so that they should all overlook, like a flight of steps, as shewn in fig. 4, where the citadel is supposed to stand on a conical hill, high above the town, (which is only defended by a glacis and covert way, surrounding a ditch and rampart) and has four rows of cannon, at different heights, each commanding the exterior defences, and the surrounding country, as far as the shot can reach. This, though not a common figure, nor a common mode of fortifying such places, (for works are rarely carried like hoops or bands around hills) will fully illustrate the general tendency of the foregoing details, and to the ordinary reader, who cannot here expect to find all the minute items and varieties abounding in this very intricate science, will give a tolerable insight into the principles on which fortifications are usually constructed.

To return to fig. 3. It will be seen that the elevation of A would, on the calculation there assumed, be such as to carry the cordon of its terre-pleine so high, that its revetement could be battered from the glacis, D O, without touching C or B. To remedy this, where such an exposure would be injurous, (for it is

in some instances expedient, as above described, to direct all the force exteriorly, especially where the outwork lays upon a navigable river, and that ships can be brought to bear upon the works,) the redoubt must be lowered to the same level of terre-pleine as the raveline : and, indeed, it may even, in some few instances, where A must be completely screened from the exterior, be proper to sink the terre-pleine of B so very low, that its cannon may just graze the terre-pleine of the raveline C ; making the parapet of a due height, and forming a substantial shed of three inch boards, &c. nearly flat, over the banquette, at a foot above the crest of the parapet. This prevents the enemy from commanding the terre-pleine of the redoubt, while, at the same time, those defending it would do ample execution through the narrow slit, or opening, between the crest and the shed. The latter would effectually keep off grenades, &c. and give the defenders great confidence. The dotted lines above the rampart A, shew the height to which its parapet would necessarily be raised, if B were elevated even a foot and a half only above C. The dotted line from C towards B shews the level to which the genouliere, or crest of the lower slope of the embrazure, may be brought, so as to allow the fire from B to graze the terre-pleine of C, and to drive the enemy from the raveline.

Relinquishing the explanation of what relates to the more scientific parts of the topic, we must now enter upon the description of many other matters, indispensably necessary on this occasion. We have already spoken of bomb-proofs. These are vaulted chambers, either running under long arches, or groined, and standing on substantial walls and pillars. The term very properly implies, that the arches should be sufficiently strong to resist the fall of shells, or, at least, to prevent their penetrating into the chambers. It generally demands, at least, a yard in thickness to produce such a firm resistance ; the masonry should be of the very best materials, and put together in a workmanlike manner. The casemates, thus arched over, should be further covered with three or four feet of soil, where such an addition would not raise the terre-pleine too high : for, by allowing a shell to bury itself completely, its splinters do not occasion half so much mischief, as when the explosion is more superficial ; although a quantity of soil may be thrown out. Perhaps the best contrivance for small casemates, defended by breast-works, is the giving them such a slope as may cause shells to fall into pits, &c. so as to do no damage. Such pits answer well in the centres of round or polygon redoubts, where only a parapet is left around the top, and might, perhaps, be advantageously made in the centre of block-houses, &c.

In the formation of magazines, for ammunition, the arches are usually made double, that is, one greater arch covers two smaller ones ; the latter resting on a central pier, as seen in fig. 5. In this case every arch should be bomb proof, and the roof should be pitched ; the end falling off by a gradual rounding, and the whole well supported by buttresses. The walls of magazines are generally double ; the buttresses are sometimes pierced at their sides with small loop-holes, for the admission of air and of light to the surrounding passage. All the fastenings should be of brass or of copper, and no wood or iron allowed in any part whatever.

The ramparts are ascended by means of long slopes, called ramps, laying in general parallel with and leaning against them : these ought always to be broad enough to admit a gun passing up and down, mounted on its carriage. The ramps into solid bastions sometimes diverge into three branches, of which two lay along the insides of the adjoining curtains, while the third runs straight up in a line with the capital, *i. e.* with the centre of the gorge, pointing towards the saliant angle. Thus H C is the capital of the bastion 4. fig. 1. Horseshoe cavaliers have usually but one ramp, placed in the centre of the rear, as shewn by the two parallel lines proceeding from that in the bastion C, of the crown work M. fig. 1.

The proper arrangement of streets within fortified towns is of the utmost importance, by contributing essentially to the ready resort of troops to their posts, and facilitating the supply of stores. Every avenue ought to have a barrier, both to keep the inhabitants under proper controul, and to prevent the effects of various stratagems in behalf of a surprise. Those houses which command the interior of the works should be always reserved for the habitations of the garrison, and should likewise be supplied with small quantities of ammunition. The arsenals should be completely covered from the fire of the enemy's batteries; and, together with every building ap-

propriated to the lodgment of troops, or of stores, &c. should be covered in with bomb proofs. The magazines should not be too large, but commodiously situated for the distribution of ammunition, and every precaution should be taken to keep all combustible stores as far as possible from the provision, &c. so that in case of the former taking fire, the garrison should not be necessitated to capitulate, owing to a want of subsistence.

Sally-ports are made under various parts of the works, to favour the sallies made occasionally, for the purpose of attacking the besiegers in their intrenchments, or for other essential purposes. These are generally galleries, which are shut up, except at the moments when in immediate use. Mines are frequently prepared in the first construction of a fortress; but the galleries whereby they are entered are usually stopped up; nor are they loaded, that is, filled with powder, until the period seems close at hand for their being serviceable. Such matters are carefully concealed from all but the engineers, and the superior officers. The supply of water, if from a river, or lake, should be very carefully secured; for this purpose, it is often necessary to enlarge the outworks, so as to command sluices, &c. whereby the ditch or reservoirs are filled. If possible, large tanks should be kept in the garrison, or a proper quantity of casks should be filled, especially in parts where wells cannot be dug: lest the besiegers should either drain off the lake, or get command of the sluices and block them up. If particular parts of the surrounding country can be inundated, it sometimes renders all attempts to carry the place by breaching the walls utterly impracticable. When this happens, and that the situation admits of its being completely invested, (whereby it is meant that all access is cut off,) the place may fall in consequence of a blockade. The chances of war are, however, greatly against the success of blockades; for, if the garrison be strong and well provided, it may make numerous successful sallies against an army which must be greatly dispersed by surrounding the place; while the diseases incident to fixed camps, bad provisions, putrid water, constant watching, and probably the necessity of countervallation throughout its rear, to keep out partisans, or to repel such forces as may hover about with the intention to relieve the place, all combine to weaken, dishearten, and cause relaxation among the besiegers. In this instance, the besieged, who have but one object, namely the defence of the works, have some advantage. But a good general will never sit down before a town he is not tolerably certain must fall in a given time.

An ample stock of ready made palisades, chevaux de frises, &c. ought to be made in time of peace, and be safely deposited, so as to be out of the reach of carcases, shells, &c.; lest they should take fire. Such machines are generally best preserved, and are safest, when immersed in water. Fascines, which are large faggots, are dangerous in a fortress, being so soon kindled, and so prompt to get into a great blaze, as to prove highly injurious. When the the soil is sandy, or of common loam or gravel, canvas bags should be kept in readines to be filled, so as to stop a breach or to raise a breast-work, &c. in case of emergency.

Every endeavour should be exerted towards obstructing the enemy from reconnoitring the form of the works, as well as their disposition before the respective parts, and their defilement. The want of information as to casemated or solid defences sometimes proves very distressing to the beseigers, who not rarely come suddenly upon works of which they had no previous information; and eventually find themselves enfiladed, or at least directly opposed by some masked battery; such as the embrasures in casemated curtains and bastions; or by redoubts within ravelines, of which they had no intelligence, and which could not be discovered from the glacis.

It sometimes occurs that, after getting possession of the works, the besiegers are compelled to quit the body of the place, and to retreat to their lodgments on the counterscarp. This, for the most part, is occasioned by the judicious situation of a citadel; or by the peculiar mode of building the houses, &c. Indeed it has more than once happened, that, as the breach was stormed, and perhaps carried, succours have entered at some opposite part of the fortress, and enabled the garrison to take the field with advantage. Sieges are, very frequently, raised by the approach of succours; and many an army, thus retiring, has been either shut up, or compelled to lay down its arms.

The great variety of favourable occurrences occasionally offering in behalf of those brave men, who, regardless of the labours, and of the painful privations to which the beseiged are ever subject, con-

tinue firm to their duty, should stimulate each individual to the utmost exertion, and to submit to every hardship without a murmur. The example of the governor, and of the officers in general, rarely fails to produce that happy effect; and, as we have so gloriously witnessed, in the case of General Elliott's defence of Gibraltar, creates an enthusiasm, that makes each man a hero! It is in such places, and in such exigences, that the man of genius may render himself conspicuous and his name immortal! The planning of defences in opposition to approaches, both numerous and stupendous in their construction, and the contrivance of interior safety, as well as the means of protracting, and of annihilating, the efforts of a numerous besieging army, composed of the flower of two nations, while they upheld the brave defenders of Gibraltar to the admiration of the world, and endeared them to their country, afford the best example, as to the duties of those who are entrusted with the defence of fortified places, and should encourage to the formation of work after work in the interior, to prolong the doubtful contest, and to hold out to the very last moment.

Fortification, under such circumstances, is certainly a most important science; and, when duly executed, often gives a turn to the balance of war, and produces the most extraordinary reverses. Record furnishes various instances of comparative handfuls of men having, by the aid of field-works, such as a line of redans or fleches, supported by redoubts, within musket-shot of each other; or of swallow-tails, that is, irregularly indented lines, and various other defences, made in favourable positions; such as rising grounds, or between two deep rivers, or around a town, or among heavy woods, so completely foiled all the attempts of large armies, as to cause their retreat, and ultimately their rout or dispersion. Field-works are generally slight, being intended only for temporary defence; they sometimes answer well for the protection of convoys, and are always most formidable when flanked by posts made in churches, mills, old castles, and a variety of such edifices. When the ground is uneven, the line should run so as to occupy the most commanding spots; at which the artillery should be principally stationed.

Field fortification is full of variety; for it is perhaps scarcely possible to point out any two stations taken by an army, in the course of many and active campaigns, that would suit the same form of defence. Hence the superior ability of an engineer become conspicious. An inferior army is obliged to intrench on the strongest ground it can command, so as to check a superior and conquering enemy, advancing rapidly to its attack. No time is left for deep research, for consultation, for substitution, or for the correction of errors: the thing must be done off hand! When such is the case, the engineer must first observe the weak points, and effectually secure them. He must then take every advantage of the strong parts; and connecting the two, so that the former shall be supported by the latter, form such a powerful range of opposition, as may at once appal the eager assailants. The knowledge of component parts, of fit proportions, and of a thousand technical requisites, are attainable by most persons of common intellect; but many possess a great depth of learning in these particulars, who, nevertheless, are wanting in the indispensable qualities of quick perception, and of ready and appropriate decision.

FORTIFIED, an appellation given to places defended by ramparts, bastions, ditches, covert-ways, half-moons, ravelines, tenailles, and other out-works. See the preceding article.

FOSS, in fortification, a hollow place, commonly full of water, lying between the scarp and counterscarp, below the rampart; and turning round a fortified place, or a post that is to be defended.

Foss *way*, one of the four principal highways of England, that anciently led through the kingdom, supposed to be made by the Romans, having a ditch upon one side thereof.

FOSSA, in our ancient customs, was used to signify a ditch full of water, wherein women convicted of felony were drowned. See Furca.

FOSSIL, in natural history, denotes, in general, every thing dug out of the earth, whether they be natives thereof, as metals, stones, salts, earths, and other minerals; or extraneous, reposited in the bowels of the earth by some extraordinary means, as earthquakes, the deluge, &c. See Mineralogy.

FOTHERGILLA, in botany, so called in memory of John Fothergill, M. D. a genus of the Polyandria Digynia class and order. Natural order of Armentaceæ, Jussieu. Essential character: calyx ament, ovate; scales one-flowered; corolla calyx-form, one-petalled, five-cleft. There is but one species.

FOTHERING, in naval affairs, a peculiar method of endeavouring to stop a

leak in the bottom of a ship, while she is afloat, either at sea or at anchor, which is performed by fastening a sail at the four corners, letting it down under the ship's bottom, and then putting a quantity of chopped rope-yarns, oakum, wool, &c. between it and the ship's side; by repeating the latter part of this operation several times, the leak generally sucks in a portion of the loose stuff, and thereby becomes in part, or altogether, stopped.

FOUL, or Foule, in the sea language, is used when a ship has been long untrimmed, so that the grass, weeds, or barnacles, grow to her sides under water. A rope is also foul, when it is either tangled in itself or hindered by another, so that it cannot run or be overhauled.

Foul, imports also the running of one ship against another. This happens sometimes by the violence of the wind, and sometimes by the carelessness of the people on board, to ships in the same convoy, and to ships in port by means of others coming in. The damages occasioned by running foul are of the nature of those in which both parties must bear a part. They are usually made half to fall upon the sufferer, and half upon the vessel which did the injury: but in cases where it is evidently the fault of the master of the vessel, he alone is to bear the damage.

Foul *water*. A ship is said to make foul water, when, being under sail, she comes into such shoal water, that though her keel does not touch the ground, yet it comes so near it, that the motion of the water under her raises the mud from the bottom.

FOUNDATION, in architecture, is that part of a building which is under ground. See Architecture and Building.

Foundation, denotes also a donation or legacy, either in money or lands, for the maintenance and support of some community, hospital, school, lecture, &c.

FOUNDER, in a general sense, the person who lays a foundation, or endows a church, school, religious house, or other charitable institution. The founder of a church may preserve to himself the right of patronage, or presentation to the living.

Founder, also implies an artist, who casts metals in various forms for different uses, as guns, bells, statues, printing characters, candlesticks, buckles, &c. whence they are denominated gun-founders, bell-founders, figure-founders, letter-founders, founders of small works, &c. See Foundery.

Founder, in the sea language. A ship is said to founder, when, by an extraordinary leak, or by a great sea breaking in upon her, she is so filled with water that she cannot be freed of it; so that she can neither veer nor steer, but lie like a log; and, not being able to swim along, will at last sink.

FOUNDERY, or Foundry, the art of casting all sort of metals into different forms. It likewise signifies the work-house, or smelting hut, wherein these operations are performed. See Iron Foundery.

Foundery *of small works, or casting in sand.* The sand used for casting small works is, at first, of a pretty soft, yellowish, and clammy nature: but it being necessary to strew charcoal dust in the mould, it at length becomes of a quite black colour. This sand is worked over and over, on a board, with a roller and a sort of knife, being placed over a trough to receive it, after it is by these means sufficiently prepared.

This done, they take a wooden board, of a length and breadth proportional to the things to be cast, and putting a ledge round it, they fill it with sand, a little moistened, to make it duly cohere. Then they take either wood or metal models of what they intend to cast, and apply them so to the mould, and press them into the sand, as to leave their impression there. Along the middle of the mould is laid half a small brass cylinder, as the chief canal for the metal to run through, when melted, into the models or patterns; and from this chief canal are placed several others, which extend to each model or pattern placed in the frame. After this frame is finished they take out the patterns, by first loosening them all round, that the sand may not give way.

Then they proceed to work the other part of the mould with the same patterns in just such another frame, only that it has pins, which, entering into holes that correspond to it in the other, make the two cavities of the pattern fall exactly on each other.

The frame thus moulded is carried to the melter, who, after extending the chief canal of the counterpart, and adding the cross canals to the several models in both, and strewing mill dust over them, dries them in a kind of oven for that purpose.

Both parts of the mould being dry, they are joined together by means of the pins; and to prevent their giving way, by reason of the melted metal passing through the chief cylindrical canal, they are screwed or wedged up like a kind of a press.

While the moulds are thus preparing, the metal is fusing in a crucible, of a size proportionate to the quantity of metal intended to be cast.

Some of these small work founders' furnaces are like a smith's forge, others stand a few feet under ground, for the more easily and safely taking out a weighty pot of metal; which is done by means of a circular tongs, that grasps round the top of the crucible. When the metal is melted, the workman pours it through the chief canal of each mould, which conveys it to every distinct pattern.

When the moulds are cool, the frames are unscrewed, or unwedged, and the cast-work taken out of the sand, which sand is worked over again for other castings.

Foundery *of statues.* The casting of statues depends on the due preparation of the pit, the core, the wax, the outer mould, the inferior furnace to melt off the wax, and the upper to fuse the metal. The pit is a hole dug in a dry place, something deeper than the intended figure, and made according to the prominence of certain parts thereof. The inside of the pit is commonly lined with stone or brick; or, when the figure is very large, they sometimes work on the ground, and raise a proper fence to resist the impulsion of the melted metal.

The inner mould, or core, is a rude mass, to which is given the intended attitude and contours. It is raised on an iron grate, strong enough to sustain it, and is strengthened within by several bars of iron. It is generally made either of potter's clay, mixed with hair and horse-dung, or of plaster of Paris, mixed with brick-dust. The use of the core is to support the wax, the shell, and lessen the weight of the metal. The iron bars and the core are taken out of the brass figure through an aperture left in it for that purpose, which is soldered up afterwards. It is necessary to leave some of the iron bars of the core, that contribute to the steadiness of the projecting part, within the brass figure.

The wax is a representation of the intended statue. If it be a piece of sculpture, the wax should be all of the sculptor's own hand who usually forms it on the core; though it may be wrought separately, in cavities moulded on a model, and afterwards arranged on the ribs of iron over the grate; filling the vacant space in the middle with liquid plaster and brick-dust, whereby the inner core, is proportioned as the sculptor carries on the wax.

When the wax, which is the intended thickness of the metal, is finished, they fill small waxen tubes perpendicular to it from top to bottom, to serve both as canals for the conveyance of the metal to all parts of the work, and as vent-holes to give passage to the air, which would otherwise occasion great disorder when the hot metal came to encompass it.

The work being brought thus far, must be covered with its shell, which is a kind of crust laid over the wax, and which, being of a soft matter, easily receives the impression of every part, which is afterwards communicated to the metal, upon its taking the place of the wax, between the shell and the mould. The matter of this outer mould is varied, according as different layers are applied. The first is generally a composition of clay and old white crucibles, well ground and sifted, and mixed up with water to the consistence of a colour fit for painting: accordingly they apply it with a pencil, laying it seven or eight times over, and letting it dry between whiles. For the second impression, they add horse-dung and natural earth to the former composition. The third impression is only horse-dung and earth. Lastly, the shell is finished by laying on several more impressions of this last matter, made very thick with the hand.

The shell, thus finished, is secured by several iron girts bound round it, at about half a foot distance from each other, and fastened at the bottom to the grate under the statue, and at the top to a circle of iron, where they all terminate.

If the statue be so big, that it would not be easy to move the moulds with safety, they must be wrought on the spot where it is to be cast. This is performed two ways: in the first, a square hole is dug under ground, much bigger than the mould to be made therein, and its inside lined with walls of free-stone or brick. At the bottom is made a hole of the same materials, with a kind of furnace, having its aperture outwards: in this is a fire made to dry the mould, and afterwards melt the wax. Over this furnace is placed the grate, and upon this the mould, &c. formed as above. Lastly, at one of the edges of the square pit is made another large furnace, to melt the metal. In the other way it is sufficient to work the mould above ground, but with the like precaution of a furnace and grate underneath. When finished, four walls are to be run around it, and by the side thereof a massive made for a melting furnace. For the rest, the method is the same in

both. The mould being finished, and inclosed as described, whether under ground or above it, a moderate fire is lighted in the furnace under it, and the whole covered with planks, that the wax may melt gently down, and run out at pipes contrived for that purpose, at the foot of the mould, which are afterwards exactly closed with earth, so soon as the wax is carried off. This done, the hole is filled up with bricks thrown in at random, and the fire in the furnace augmented, till such time as both the bricks and mould become red hot. After this, the fire being extinguished, and every thing cold again, they take out the bricks, and fill up their place with earth, moistened and a little beaten, to the top of the mould, in order to make it the more firm and steady. These preparatory measures being duly taken, there remains nothing but to melt the metal, and run it into the mould. This is the office of the furnace above described, which is commonly made in the form of an oven, with three apertures, one to put in the wood, another for a vent, and a third to run the metal out at. From this last aperture, which is kept very close while the metal is in fusion, a small tube is laid, whereby the melted metal is conveyed into a large earthen basin over the mould, into the bottom of which all the big branches of the jets or casts, which are to convey the metal into all the parts of the mould, are inserted.

These casts, or jets, are all terminated with a kind of plugs, which are kept close, that, upon opening the furnace, the brass, which gushes out with violence, may not enter any of them, till the basin be full enough of matter to run into them all at once. Upon which occasion, they pull out the plugs, which are long iron rods, with a head at one end, capable of filling the whole diameter of each tube. The whole of the furnace is opened with a long piece of iron, fitted at the end of each pole, and the mould filled in an instant. This completes the work in relation to the casting part; the rest being the sculptor's or carver's business, who, taking the figure out of the mould and earth wherewith it is encompassed, saws off the jets with which it appears covered over, and repairs it with chisels, gravers, puncheons, &c.

Foundery *of bells*. The metal for bells has already been described. See Bell.

The dimensions of the core, and the wax, for bells, if a ring of bells especially, are not left to chance, but must be measured on a scale, or diapason, which gives the height, aperture, and thickness necessary for the several tones required. It is on the wax that the several mouldings, and other ornaments, are formed, to be represented in relievo on the outside of the bell.

The business of bell-foundery is reducible to three particulars: the proportion of a bell; the forming of the mould; and the melting of the metal.

The proportions of our bells differ much from those of the Chinese: in ours the modern proportions are, to make the diameter fifteen times the thickness of the brim, and twelve times the height.

There are two kinds of preparation, viz. the simple and the relative: the former are those proportions only that are between the several parts of a bell, to render it sonorous; the relative proportions establish a requisite harmony between several bells.

The particulars necessary for making the mould of a bell, are, 1. The earth; the most cohesive is the best: it must be well ground and sifted, to prevent any chinks. 2. Brick-stone; which must be used for the mine, mould, or core, and for the furnace. 3. Horse-dung, hair, and hemp, mixed with the earth, to render the cement more binding. 4. The wax for incriptions, coats of arms, &c. 5. The tallow, equally mixed with the wax, in order to put a slight lay of it upon the outer mould, before any letters are applied to it. 6. The coals to dry the mould.

For making the mould, they have a scaffold, consisting of four boards, ranged upon tressels. Upon this they carry the earth, grossly diluted, to mix it with horse dung, beating the whole with a large spatula.

The compasses of construction is the chief instrument for making the mould, which consists of two different legs, joined by a third piece. And last of all, the founder's shelves, on which are the engravings of the letters, cartridges, coats of arms, &c.

They first dig a hole of a sufficient depth to contain the mould of the bell, together with the case, or cannon, under ground; and about six inches lower than the terre-pleine, where the work is performed. The hole must be wide enough for a free passage between the mould and walls of the hole; or between one mould and another, when several bells are to be cast. At the centre of the hole is a stake erected, that is strongly fastened in the ground. This supports an iron peg, on which the pivot of the second branch

of the compasses turns. The stake is encompassed with a solid brick-work, perfectly round, about half a foot high, and of the proposed bell's diameter. This they call a mill-stone. The parts of the mould are the core, the model of the bell, and the shell. When the outer surface of the core is formed, they begin to raise the core, which is made of bricks that are laid in courses of equal height upon a lay of plain earth. At the laying each brick they bring near it the branch of the compasses, on which the curve of the core is shaped, so as that there may remain between it and the curve the distance of a line, to be afterwards filled up with layers of cement. The work is continued to the top, only leaving an opening for the coals to bake the core. This work is covered with a layer of cement, made of earth and horse-dung, on which they move the compasses of construction, to make it of an even smoothness every where.

The first layer being finished, they put the fire to the core, by filling it half with coals, through an opening that is kept shut during the baking, with a cake of earth, that has been separately baked. The first fire consumes the stake, and the fire is left in the core half, or sometimes a whole day: the first layer being thoroughly dry, they cover it with a second, third, and fourth; each being smoothed by the board of the compasses, and thoroughly dried before they proceed to another.

The core being completed, they take the compasses to pieces, with intent to cut off the thickness of the model, and the compasses are immediately put in their place, to begin a second piece of the mould. It consists of a mixture of earth and hair, applied with the hand on the core, in several cakes that close together. This work is finished by several layers of a thinner cement of the same matter, smoothed by the compasses, and thoroughly dried, before another is laid on. The first layer of the model is a mixture of wax and grease spread over the whole. After which are applied the inscriptions, coats of arms, &c. besmeared with a pencil dipped in a vessel of wax in a chafing-dish: this is done for every letter. Before the shell is begun, the compasses are taken to pieces, to cut off all the wood that fills the place of the thickness to be given to the shell.

The first layer is the same earth with the rest, sifted very fine; whilst it is tempering in water, it is mixed with cow's hair, to make it cohere. The whole, being a thin cullis, is gently poured on the model, that fills exactly all the sinuosities of the figures, &c. and this is repeated till the whole is two lines thick over the model. When this layer is thoroughly dried, they cover it with a second of the same matter, but something thicker: when this second layer becomes of some consistence, they apply the compasses again, and light a fire in the core, so as to melt off the wax of the inscriptions, &c.

After this, they go on with other layers of the shell, by means of the compasses. Here they add to the cow's hair a quantity of hemp, spread upon the layers, and afterwards smoothed by the board of the compasses. The thickness of the shell comes to four or five inches lower than the mill-stone before observed, and surrounds it quite close, which prevents the extravasation of the metal. The wax should be taken out before the melting of the metal.

The ear of the bell requires a separate work, which is done during the drying of the several incrustations of the cement. It has seven rings; the seventh is called the bridge, and unites the others, being a perpendicular support to strengthen the curves. It has an aperture at the top, to admit a large iron peg, bent at the bottom; and this is introduced into two holes in the beam, fastened with two strong iron keys. There are models made of the rings, with masses of beaten earth, that are dried in the fire, in order to have the hollow of them. These rings are gently pressed upon a layer of earth and cow's hair, one half of its depth; and then taken out, without breaking the mould. This operation is repeated twelve times for twelve half-moulds, that two and two united may make the hollows of the six rings: the same they do for the hollow of the bridge, and bake them all, to unite them together.

Upon the open place left for the coals to be put in are placed the rings that constitute the ear. They first put into this open place the iron ring to support the clapper of the bell; then they make a round cake of clay, to fill up the diameter of the thickness of the core. This cake, after baking, is clapped upon the opening, and soldered with a thin mortar spread over it, which binds the cover close to the core.

The hollow of the model is filled with an earth sufficiently moist to fix on the place, which is strewed at several times upon the cover of the core; and they

beat it gently with a pestle to a proper height; and a workman smooths the earth at top with a wooden trowel dipped in water.

Upon this cover, to be taken off afterwards, they assemble the hollows of the rings. When every thing is in its proper place, they strengthen the outsides of the hollows with mortar, in order to bind them with the bridge, and keep them steady at the bottom, by means of a cake of the same mortar, which fills up the whole aperture of the shell. This they let dry, that it may be removed without breaking. To make room for the metal, they pull off the hollows of the rings through which the metal is to pass, before it enters into the vacuity of the mould. The shell being unloaded of its ear, they range under the mill-stone five or six pieces of wood, about two feet long, and thick enough to reach almost the lower part of the shell; between these and the mould they drive in wooden wedges with a mallet, to shake the shell of the model whereon it rests, so as to be pulled up, and got out of the pit.

When this and the wax are removed, they break the model and the layer of earth, through which the metal must run, from the hollow of the rings, between the bell and the core. They smoke the inside of the shell, by burning straw under it, that helps to smooth the surface of the bell. Then they put the shell in the place, so as to leave the same interval between that and the core; and before the hollows of the rings or the cap are put on again, they add two vents, that are united to the rings, and to each other, by a mass of baked cement. After which they put on this mass of the cap, the rings, and the vent, over the shell, and solder it with thin cement, which is dried gradually, by covering it with burning coals. Then they fill up the pit with earth, beating it strongly all the time round the mould.

The furnace has a place for the fire, and another for the metal. The fire-place has a large chimney, with a spacious ash-hole. The furnace, which contains the metal, is vaulted, whose bottom is made of earth, rammed down; the rest is built with brick. It has four apertures; the first, through which the flame reverberates; the second is closed with a stopple, that is opened for the metal to run; the others are to separate the dross, or scoriæ, of the metal by wooden rakes: through these last apertures passes the thick smoke. The ground of the furnace is built sloping, for the metal to run down.

Foundery, *of great guns and mortar-pieces.* The method of casting these pieces is little different from that of bells; they are run massy, without any core, being determined by the hollow of the shell; and they are afterwards bored with a steel trepan, that is worked either by horses or a water-mill or steam.

Foundery, *Letter, or casting of printing types.* The first thing requisite is to prepare good steel punches, on the face of which is drawn the exact shape of the letter with pen and ink, if the letter be large; or with a smooth blunted point of a needle, if small; and then, with proper gravers, the cutter digs deep between the strokes, letting the marks stand on the punch; the work of hollowing being generally regulated by the depth of the counter punch: then he files the outside, till it is fit for the matrice.

They have a mould to justify the matrices by, which consists of an upper and under part; both these are alike, except the stool and spring behind, and a small roundish wire in the upper part, for making the nick in the shank of the letter. These two parts are exactly fitted into each other, being a male and female gage, to slide backwards and forwards.

Then they justify the mould, by casting about twenty samples of letters, which are set in a composing stick, with the nicks towards the right hand; and comparing these every way with the pattern letters, set up in the same manner, they find the exact measure of the body to be cast.

Next they prepare the matrice, which is of brass or copper, an inch and a half long, and of a proportionable thickness to the size of the letter it is to contain. In this metal is sunk the face of the letter, by striking the letter-punch the depth of an *n*. After this, the sides and face of the matrice are justified, and cleared, with files, of all bunchings that have been made by sinking the punch.

Then it is brought to the furnace, which is built upright of brick, with four square sides and a stone at top, in which is a hole for the pan to stand in. They have several of these furnaces.

Printing-letters are made of lead, hardened with iron or stub-nails. To make the iron run, they mingle an equal weight of antimony, beaten small in an iron mor-

tar, and stub-nails together. They charge a proper number of earthen pots that bear the fire with the two ingredients, as full as they can hold, and melt it in an open furnace built for that purpose. When it bubbles, the iron is then melted, but it evaporates very much. This melted compost is ladled into an iron pot, wherein is melted lead, that is fixed on a furnace close to the former, *3lb.* of melted iron to *25lb.* of lead; this they incorporate according to art.

The caster, taking the pan off the stone, and having kindled a good fire, he sets the pan in again, and metal in it to melt. If it be a small-bodied letter, or a thin letter with great bodies, that he intends to cast, his metal must be very hot, and sometimes red-hot, to make the letter come. Then taking a ladle, of which he has several sorts, that will hold as much as will make the letter and break, he lays it at the hole where the flame bursts out; then he ties a thin leather, cut with its narrow end against the face, to the leather groove of the matrice, by whipping a brown thread twice about the leather groove, and fastening the thread with a knot. Then he puts both pieces of the mould together, and the matrice into the matrice-cheek, and places the foot of the matrice on the stool of the mould, and the broad end of the leather on the wood of the upper haft of the mould, but not tight up, lest it hinder the foot of the matrice from sinking close down upon the stool, in a train of work. Afterwards, laying a little resin on the upper part of the mould, and having his casting-ladle hot, he, with the boiling side, melts the resin, and presses the broad end of the leather hard down on the wood, and so fastens it thereto. Now he comes to casting, when placing the under half of the mould in his left hand, with the hook or jag forward, he holds the end of its wood between the lower part of the ball of his thumb and his three hinder fingers; then he lays the upper half of the mould upon the under half, so as the male gages may fall into the female; and, at the same time, the foot of the matrice places itself upon the stool, and clasping his left hand thumb strongly over the upper half, he nimbly catches hold of the bow or spring, with his right hand fingers at the top of it, and his thumb under it, and places the point of it against the middle of the notch in the backside of the matrice, pressing it forwards, as well towards the mould as downwards, by the shoulder of the notch, close upon the stool, while at the same time, with his hinder fingers, as aforesaid, he draws the under half of the mould towards the ball of his thumb, and thrusts, by the ball of his thumb, the upper part towards his fingers, that both the registers of the mould may press against both sides of the matrice, and his thumb and fingers press both sides of the mould close together.

Then he takes the handle of his ladle in his right hand, and with the ball of it gives two or three strokes outwards upon the surface of the melted metal, to clear it of the scum; then he takes up the ladle full, and having the mould in the left hand, turns his left side a little from the furnace, and brings the geat of his ladle to the mouth of the mould; and turns the upper part of his right hand towards him, to pour the metal into it, while, at the same instant, he puts the mould in his left hand forwards, to receive the metal with a strong shake, not only into the bodies of the mould, but, while the metal is yet hot, into the very face of the matrice, to receive its perfect form there as well as in the shank. Then he takes the upper half of the mould off, by placing his right thumb on the end of the wood next his left thumb, and his two middle fingers at the other end of the wood: he tosses the letter, break and all, out upon a sheet of waste paper, laid on a bench a little beyond his left hand; and then is ready to cast another letter as before, and likewise the whole number in that matrice.

Then boys, commonly employed for this purpose, separate the breaks from the shanks, and rub them on a stone, and afterwards a man cuts them all of an even height, which finishes the fount for the use of the printer. See the next article. A workman will ordinarily cast 3000 of these letters in a day. The perfection of letters thus cast consists in their being all severally square and straight on every side; and all generally of the same height, and evenly lined, without stooping one way or other; neither too big in the foot nor the head; well grooved, so as the two extremes of the foot contain half the body of the letter; and well ground, barbed, and scraped with a sensible notch, &c. See PRINTING,

FOUNT, or FONT, among printers, a set or quantity of letters, and all the appendages belonging thereto, as numeral characters, quadrats, points, &c. cast by a letter-founder, and sorted. Founts are

large or small, according to the demand of the printer, who orders them by the hundred weight, or by sheets. When a printer orders a fount of five hundred, he means that the fount, consisting of letters, points, spaces, quadrats, &c. shall weigh 500*lb*. When he demands a fount of ten sheets, it is understood, that with that fount he shall be able to compose ten sheets, or twenty forms, without being obliged to distribute. The founder takes his measures accordingly; he reckons 120*lb*. for a sheet, including the quadrats, &c. or 60*lb*. for a form, which is only half a sheet: not that the sheet always weighs 120*lb*., or the form 60*lb*.; on the contrary, it varies according to the size of the form: besides, it is always supposed that there are letters left in the cases. As, therefore, every sheet does not comprehend the same number of letters, nor the same sort of letters, we must observe, that, as in every language some sounds recur more frequently than others, some letters will be in much more use, and oftener repeated than others, and consequently their cells or cases should be better stored than those of the letters which do not recur so frequently: thus, a fount does not contain an equal number of *a* and *b*, or of *b* and *c*, &c. the letter-founders have therefore a list or tariff, or, as the French call it, a police, by which they regulate the proportions between the different sorts of characters that compose a fount: and it is evident that this tariff will vary in different languages, but will remain the same for all sorts of characters employed in the same language. Suppose a fount of 100,000 characters, which is a common fount; here *a* should have 5000; *c*, 3000; *e*, 11,000; *i*, 6000; *m*, 3000; the *k*, only 300; and the *x*, *y*, and *z*, not many more.

FOUNTAIN, in philosophy, a spring or source of water, rising out of the earth. Among the ancients, fountains were held sacred, and even worshipped as a kind of divinities. For the phænomena, theory, and origin of fountains or springs, see SPRING.

FOUNTAIN, or *Artificial Fountain*, in hydraulics, called also a *jet d'eau*, is a contrivance, by which water is violently spouted upwards. See HYDRAULICS.

FOUNTAIN *pen*. See PEN.

FOURTH, in music, one of the harmonical intervals, called concords. It is called fourth, as containing four sounds or terms between its extremes, and three intervals; or, as being the fourth in order of the natural or diatonic scale from the fundamental. The ancients called it diatessaron, and speak of it as the principal concord, on whose divisions all the rest depend; but the moderns, so far from allowing it such perfections, find it one of the most imperfect, and even dispute whether it ought to be received among the number of concords at all. It consists in the mixture of two sounds in the ratio of 4 : 3; that is, of two sounds produced by two chords, whose lengths, &c. are in that proportion.

FOWLING, the art of taking or killing birds. It is either practised as an amusement by persons of rank and property, and then principally consists in killing them with a light fire-arm, called a fowling-piece, and the diversion is secured to them by the game-laws; or it is practised for a livelihood, by persons who use nets and other apparatus. Though there is much skill and knowledge displayed in fowling with the fowling-piece, not only in the use of the instrument, but likewise in the training of dogs, and discovering and starting the game, we must, from the nature of our limits, avoid entering into this subject. The other artifices, by which birds are taken, consist in imitating their voices, or leading them, by other means, into situations, where they become entrapped by nets, or bird-lime, or otherwise.

The pipe, or call, affords the most common means used to take great numbers of birds; this is done in the months of September and October. A thin wood is the spot chosen for this purpose; under a tree, a little distant from the others, is erected a cabin, and there are only those branches left on the tree, which are necessary for the placing of the bird-lime, which are supple twigs, and are covered with bird-lime. There are placed around the cabin avenues with twisted perches, which are also besmeared with bird-lime. The bird-catcher places himself in the cabin, and at sun-rise and sun-set imitates the cry of a small bird, calling the others to its assistance; for animals have also their cries to express their different passions, which are well known to each other. If a cry is made to imitate the owl, immediately different sorts of birds assemble at the cry of their common enemy, and they are seen falling to the ground at every instant, their wings, from the bird-lime, being of no use to them. The cries of those birds which are thus caught attract others, and great quantities are in this manner taken. It is only

during the night that the great and small owls are taken, by counterfeiting the cry of the mouse.

To take the lark, nets are spread, and about the middle of the net is placed a looking-glass, to which a cord is attached, which, upon being drawn, makes the glass turn round like the sails of a windmill; during the time that the sun shines, it is put in motion, its brilliancy attracts the larks, whose feet get entangled in the meshes of the nets. The clap-net is also made use of during the night; this is a large slender net, which is supported at each end by two men upon long poles; they walk about the ground until they hear the larks, when they let it fall, and take by this means vast quantities.

Water-fowl may be taken in great numbers, by nets properly managed. The net for this purpose should be always made of the smallest and strongest packthread that can be got. The meshes may be large, but the nets should be lined on both sides with other smaller nets, every mesh of which is to be about an inch and a half square, each way, that as the fowls strike either through them, or against them, the smaller may pass through the great meshes, and so streighten and entangle the fowl.

These nets are to be pitched for every evening-flight of fowl, about an hour before sun-set, staking them on each side of the river, about half a foot within the water, the lower side of the net being so plummed, that it may sink so far, and no farther; place the upper side of the net slantwise, shoaling against the water, but not touching it by nearly two feet; and let the strings which support this upper side of the net be fastened to small yielding sticks set in the bank; these, as the fowl strikes, will give the net liberty to play, and to entangle them. Several of these nets should be placed at once over different parts of the river, at about twelvescore fathoms distance one from another; and if any fowl come that way, the sportsman will have a share of them. It is a good method, when the nets are set, to go to places sufficiently distant from them with a gun, to frighten them towards the places where the nets are; and wherever any of the fowl are started from, it may not be amiss to plant some nets also there, to take them as they return. The nets are to be left thus placed all night, and in the morning, the sportsman is to go and see what is caught; he should visit the river first, and take up what are caught there; and, frightening the rest away to the other places where his nets are, he is next to visit them, and take what are there secured.

The Ceylonese have great plenty of water-fowl wild on their island, and have a very remarkable way of catching them, which is this: the fowler enters a lake or other water, which has a good bottom, and is not very deep; he puts an earthen pot upon his head, in which there are bored holes, through which he can see; he keeps himself so bent down in the water, that only the pot is above the surface; in this manner he enters the place where the wild-fowl are in clusters, and they think it is only some floating block. He then takes some one by the legs, and gently draws it under water, and wrings its neck till he has killed it; then putting it into his bag, which is fastened about his middle, he takes hold of another in the same manner, and so on, till he has got as many as he can carry off, and then he goes back in the same manner in which he came, not disturbing the rest of the birds, who never miss their companions, as they seem to dive down for their diversion, when the fowler pulls them under. In places where this has been practised so long, or so carelessly, that the birds are shy, the fowler uses a gun; but this he does in the following manner: he makes a screen of about five feet high, and three feet wide, which he carries in one hand straight between himself and his game, and in the other hand his gun. The birds are not alarmed at what appears only a bush; for this screen is always covered with branches of trees, fresh cut down, and full of leaves, so that the sportsman behind advances as near as he pleases, and then putting the gun through some crevice of the screen, he fires. See Decoy.

Fowling, was formerly used for the pursuing and taking birds with hawks, more properly called falconry.

Fowling *piece*, a light gun for shooting birds. That piece is always reckoned best, which has the barrel from 5½ to 6 feet, with a moderate bore; though every fowler should have them of different sizes, suitable to the game he designs to kill. The barrel should be well polished and smooth within, and the bore of an equal bigness from one end to the other; which may be proved by putting in a piece of pasteboard, cut of the exact roundness of the top; for if this goes down without stops or slipping, you may conclude the bore good. The bridge-pan must be somewhat above the touch-hole, and ought to have a notch to let down a little powder; this will prevent the piece from recoiling, which it would otherwise be apt

to do. As to the locks, choose such as are well filed, with true work, whose springs must be neither too strong nor too weak. The hammer ought to be well hardened, and pliable, to go down to the pan with a quick motion.

In shooting, observe to do it, if possible, with the wind, not against it; and rather sideways, or behind the fowl, than full in their faces. Observe also to choose the most convenient shelter you can find, as a hedge, bank, tree, or the like. Take care to have your dogs under good command, that they may not dare to stir till you give the word, after discharging your piece; for some ill taught dogs will, upon only the snap of the cock, presently rush forward, and spoil your sport. If you have not shelter enough, you must creep upon your hands and knees.

FOX, in zoology, an animal of the dog-kind. See CANIS.

Fox *glove*, in botany. See DIGITALIS.

FRACTION, in arithmetic and algebra, is a part or parts of something considered as an unit or integer. Fractions are distinguished into vulgar or common, and sexagesimal and decimal. See SEXAGESIMALS and DECIMAL.

Vulgar fractions, called also simply fractions, consist of two parts or quantities, one wrote over the other, with a line between them. The quantity placed above the line is called the numerator of the fraction; and the quantity placed under the line the denominator.

Thus, $\frac{2}{3}$ expresses the quotient of 2, divided by 3, and 2 is the numerator, and 3 the denominator. If the numerator of a fraction is equal to its denominator, then the fraction is equal to unity: thus, $\frac{4}{4} = 1$, and $\frac{a}{a}$ or $\frac{b}{b}$ are likewise equal to unity. If the numerator is greater than the denominator, then the fraction is greater than unit. In both these cases, the fraction is called improper; but if the numerator is less than the denominator, then the fraction is less than unit, and is called proper: thus $\frac{5}{3}$ is an improper fraction, but $\frac{3}{4}$ or $\frac{2}{3}$ are proper fractions. A mixed quantity is that whereof one part is an integer, and the other a fraction; as $3\frac{4}{5}$, $5\frac{2}{3}$, and $a+\frac{a^2}{b}$. See ALGEBRA.

FRACTURE, in surgery, a rupture of a bone, or a solution of continuity in a bone, when it is crushed or broken by some external cause. See SURGERY.

FRÆNUM, in anatomy, a term applied to some membraneous ligaments of the body.

FRÆNUM, *linguæ*, the ligament under the tongue, which sometimes ties it down too close to the bottom of the mouth; and then requires to be incised or divided, in order to give this organ its proper and free motion.

FRAGARIA, in botany, English *strawberry*, a genus of the Icosandria Polygynia class and order. Natural order of Senticosæ. Rosaceæ, Jussieu. Essential character: calyx ten-cleft; petals five; receptacle of the seeds ovate, and like a berry. There are three species, and many varieties.

FRAIL, a basket made of rushes, or the like, in which are packed up figs, raisins, &c. It signifies also a certain quantity of raisins, about 75 pounds.

FRAISE, in fortification, a kind of defence, consisting of pointed stakes, six or seven feet long, driven parallel to the horizon into the retrenchments of a camp, a half-moon, or the like, to prevent any approach or scalade.

Fraises differ from pallisades chiefly in this, that the latter stand perpendicular to the horizon, and the former jet out parallel to the horizon, or nearly so, being usually made a little sloping, or with the points hanging down. Fraises are chiefly used in retrenchments and other works thrown up of earth; sometimes they are found under the parapet of a rampart, serving instead of the cordon of stone used in stone-works.

FRANK, or FRANC, meaning literally free from charges and impositions, or exempt from public taxes, has various significations in our ancient customs.

FRANK, or FRANC, an ancient coin, either of gold or silver, struck and current in France. The value of the gold frank was somewhat more than that of the gold crown; the silver frank was a third of the gold one; this coin is long out of use, though the term is still retained as the name of a money of account; in which sense it is equivalent to the livre, or twenty sols.

FRANKENIA, in botany, so named in honour of John Frankenius, professor of botany at Upsala, a genus of the Hexandria Monogynia class and order. Natural order of Calycanthemæ. Caryophyllæ, Jussieu. Essential character: calyx five-cleft, funnel-form; petals five; stigma six parted; capsule one-celled, three-valved. There are three species.

FRANKFORT *black*, is the chief ingredient in the copper-plate printer's

ink: it is made of the lees of wine, burnt, washed in water, and ground in mills, together with ivory, or the stones from peaches and other fruit. The best is that made at Frankfort on the Maine, though a great deal is made at Mentz, Strasburg, and different parts of France.

FRANKINCENSE, is a gummy resin, the product of the juniperus lycia, consisting of equal parts of gum and resin; the first is soluble in water, the other in alcohol. It is brought from Turkey and the East Indies, but is principally collected in Arabia. It usually comes to us in drops, but in a very impure state, a hundred pounds not yielding more than from forty to fifty pounds of pure frankincense.

FRANKLIN, (Dr. Benjamin), in biography, one of the most celebrated philosophers and politicians of the eighteenth century, was born in Boston, in North America, in the year 1706, being the youngest of thirteen children. His father was a tallow-chandler in Boston, and young Franklin was taken away from school, at ten years of age, to assist him in his business. In this situation he continued two years, but disliking this occupation, he was bound apprentice to an elder brother, who was then a printer in Boston, but had learned that business in London, and who, in the year 1721, began to print a newspaper, being the second ever published in America; the copies of which our author was sent to distribute, after having assisted in composing and printing it. Upon this occasion our young philosopher enjoyed the secret and singular pleasure of being the much-admired author of many essays in this paper, a circumstance which he had the address to keep a secret even from his brother himself, and this when he was only fifteen years of age. The frequent ill usage from his brother induced young Franklin to quit his service, which he did at the age of seventeen, and went to New-York; but not meeting employment here, he went forward to Philadelphia, where he worked with a printer a short time; after which, at the instance of Sir William Keith, governor of the province, he returned to Boston, to solicit pecuniary assistance from his father to set up a printing-house for himself at Philadelphia, upon the promise of great encouragement from Sir William, &c. His father thought fit, however, to refuse such aid, alleging that he was yet too young (eighteen years old) to be entrusted with such a concern, and our author again returned to Philadelphia without it. Upon this Sir William said he would advance the sum himself, and our young philosopher should go to England and purchase all the types and materials himself, for which purpose he would give him letters of credit. He could never, however, get these letters, yet, by dint of fair promises of their being sent on board the ship after him, he sailed for England, expecting these letters of credit were in the governor's packet, which he was to receive upon its being opened. In this he was cruelly deceived, and thus he was sent to London, without money, friends, or credit, at the age of eighteen.

He soon found employment, however, as a journeyman printer, first at Mr. Palmer's, and afterwards with Mr. Watts, with whom he worked a considerable time, and by whom he was greatly esteemed, being also treated with such kindness that it was always most gratefully remembered by our philosopher.

After a stay of eighteen months in London, he returned to Philadelphia, *viz.* in 1726, along with a merchant of that town, as a clerk, on a salary of fifty pounds a year. But his master dying a year after, he again engaged to direct the printing business of the same person with whom he had worked before. After continuing with him the best part of a year, our philosopher, in partnership with another young man, at length set up a printing-house himself.

Before this time young Franklin had graduallly associated a number of persons like himself, of a rational and philosophical turn of mind, and formed them into a club or society, to hold meetings, to converse and communicate their sentiments together, for their mutual improvement in all kinds of useful knowledge, which was in much repute for many years afterwards. Among many other useful regulations, they agreed to bring such books as they had into one place, to form a common library. This resource being found defective, at Franklin's persuasion, they resolved to contribute a small sum monthly towards the purchase of books for their use from London. Thus their stock began to increase rapidly, and the inhabitants of Philadelphia, being desirous of having a share in their literary knowledge, proposed that the books should be lent out for paying a small sum for the indulgence. Thus, in a few years, the society became rich, and possessed more books than were, perhaps, to be found in all the other colonies. The

collection was advanced into a public library, and the other colonies, sensible of its advantage, began to form similar plans, from whence originated the libraries at Boston, New-York, Charleston, &c.; that of Philadelphia being now scarcely inferior to any in Europe.

About 1728, or 1729, young Franklin set up a newspaper, the second in Philadelphia, which proved very profitable, and otherwise useful, as affording an opportunity of making himself known as a political writer, by inserting several of his writings of that kind into it. In addition to his printing-house, he set up a shop to sell books and stationary, and in 1730 he married his wife, who proved very useful in assisting to manage the shop, &c. He afterwards began to have some leisure, both for reading books and writing them, of which he gave many specimens from time to time. In 1732 he began to publish poor Richard's Almanack, which was continued for many years. It was always remarkable for the numerous and valuable concise maxims it contained for the economy of human life, all tending to exhort to industry and frugality; and in the almanack for the last year, all the maxims were collected in an address to the reader, entitled The Way to Wealth. This has been translated into various languages, and inserted in various publications. It has also been printed on a large sheet, proper to be framed and hung up in conspicuous places in all houses, as it very well deserves to be. Mr. Franklin became gradually more known for his political talents, and in the year 1736, he was appointed clerk to the general assembly of Pennsylvania, and was re-elected by succeeding assemblies for several years, till he was chosen representative for the city of Philadelphia: and in 1737 he was appointed post-master to that city. In 1738 he formed the first fire company there, to extinguish and prevent fires, and the burning of houses; an example which was soon followed by other persons and other places. And soon after he suggested the plan for an association for insuring houses and ships from losses by fire, which was adopted, and the association continues to this day. In the year 1744, during a war between France and Great Britain, some French and Indians made inroads upon the frontier inhabitants of the province, who were unprovided for such an attack; the situation of the province was at that time truly alarming, being destitute of every means of defence. At this crisis Franklin stepped forth, and proposed to a meeting of the citizens of Philadelphia, a plan of a voluntary association for the defence of the province. This was approved of and signed by 1200 persons immediately. Copies of it were circulated through the province, and in a short time the number of signatures amounted to 10,000. Franklin was chosen colonel of the Philadelphia regiment, but he did not think proper to accept of the honour.

Pursuits of a different nature now occupied the greatest part of his attention for some years. Being always much addicted to the study of natural philosophy, and the discovery of the Leyden experiment in electricity having rendered that science of general curiosity, Mr. Franklin applied himself to it, and soon began to distinguish himself in that way. He engaged in a course of electrical experiments with all the ardour and thirst for discovery which characterized the philosophers of that day. By these he was enabled to make a number of important discoveries, and to propose theories to account for various phenomena, which have been generally adopted, and will probably endure for a long time. His observations he communicated in a series of letters to his friend Mr. Collinson, the first of which is dated March 28, 1747. In these he makes known the power of points in drawing and throwing off the electric matter, which had hitherto escaped the notice of electricians. He also made the discovery of *plus* and *minus*, and of *positive* and *negative* states of electricity; from whence, in a satisfactory manner, he explained the phenomena of the Leyden phial, first observed by Cuneus, or Muschenbroech, which had much preplexed philosophers. He shewed that the bottle, when charged, contained no more electricity than before, but that as much was taken from one side as was thrown on the other, and that to discharge it, it was necessaryto make a communication between the two sides, by which the equilibrium might be restored, and that then no signs of electricity would remain. He then demonstrated by experiments, that the electricity did not reside in the coating, as had been supposed, but in or upon the glass itself. After a phial was charged, he removed the coating, and found that, upon applying a new coating, the shock might still be received. In the year 1749 he first suggested his idea of explaining the phenomena of thunder-gusts, and of the aurora borealis, upon

electrical principles. He pointed out many particulars in which lightning and electricity agreed, and he adduced many facts, and reasoning from facts, in support of his positions. In the same year he conceived the bold and grand idea of ascertaining the truth of his doctrine, by actually drawing down the forked lightning by means of sharp pointed iron rods, raised in the region of the clouds, from whence he derived his method of securing buildings and ships from lightning. It was not until the summer of 1752 that he was enabled to complete his grand discovery of the electrical kite, which being raised up into the clouds, brought thence the electricity, or lightning, down to the earth, and M. D'Alebard made the experiment about the same time in France, by following the track which Franklin had before pointed out.

The letters which he sent to Mr. Collinson, it is said, were refused a place among the papers of the Royal Society of London, and Mr. Collinson published them in a separate volume, under the title of New Experiments and Observations on Electricity, made at Philadelphia, in America; which were read with avidity, and soon translated into different languages. His theories were at first opposed by many philosophers, some of them members of the Royal Society of London; but in 1755, when he returned to that city, they voted him the gold medal, which is annually given to the person who presents the best paper on some interesting subject. He was also admitted a member of the society, and had the degree of doctor of laws conferred upon him by several universities; but at this time, by reason of the war which broke out between Great Britain and France, he returned to America, and interested himself in the public affairs of that country. Indeed, he had done this long before; for although philosophy was a principal object in Franklin's pursuit for several years, he did not confine himself to it alone. In the year 1747 he became a member of the General Assembly of Philadelphia. Being a friend to the rights of the people from his infancy, he soon distinguished himself as a steady opponent to the unjust schemes of the proprietaries. He was soon looked up to as the head of the opposition, and to him have been attributed many of the spirited replies of the Assembly to the messages of the governors. His influence in that body was very great; this arose not from any superior powers of eloquence; he spoke but seldom, and he was never known to make an elaborate harangue; his speeches often consisted of a single sentence, or a well told story, the moral of which was always obviously to the point. He never attempted the flowery fields of oratory; his manner was plain and mild; his style in speaking was like that of his writings, simple, unadorned, and remarkably concise. With this plain manner, and his penetrating and solid judgment, he was able to confound the most eloquent and subtle of his adversaries, to confirm the opinions of his friends, and to make converts of the unprejudiced who had opposed him; with a single obervation he has rendered of no avail a long and elegant discourse, and determined the fate of a question of importance.

In the year 1749, he proposed the plan of an academy, to be erected in the city of Philadelphia, as a foundation for posterity to erect a seminary of learning more extensive and suitable to future circumstances; and in the beginning of 1750, three of the schools were opened, namely, the Latin and Greek schools, the Mathematical and the English schools. This foundation soon after gave rise to another more extensive college, incorporated by charter, May 27, 1755, which still subsists, and in a very flourishing condition. In 1752, he was instrumental in the establishment of the Pennsylvania Hospital, for the cure and relief of indigent invalids, which has proved of the greatest use to that class of persons. Having conducted himself so well as Post-master to Philadelphia, he was, in 1753, appointed Deputy Post-master General to the whole of the British colonies.

The colonies being much exposed in their frontiers to depredations by the Indians and the French; at a meeting of commissioners for several provinces, Mr. Franklin proposed a plan for their general defence, to establish in the colonies a general government, to be administered by a president general, appointed by the crown, and by a grand council, consisting of members chosen by the representatives of the different colonies; a plan which was unanimously agreed to by the commissioners present. The plan, however, had a singular fate: it was disapproved of by the ministry of Great Britain, because it gave too much power to the representatives of the people; and it was rejected by every assembly, as giving to the president general, who was to be the representative of

the crown, an influence greater than appeared to them proper in a plan of government intended for freemen. Perhaps this rejection, on both sides, is the strongest proof that could be adduced of the excellence of it, as suited to the situation of Great Britain and America at that time. It appears to have steered directly in the middle, between the opposite interests of both. Whether the adoption of this plan would have prevented the separation of America from Great Britain, is a question which might afford much room for speculation.

In the year 1755, General Braddock, with some regiments of regular troops and provincial levies, was sent to dispossess the French of the posts upon which they had seized in the back settlements. After the men were all ready, a difficulty occurred which had nearly prevented the expedition : this was the want of waggons. Franklin now stepped forward, and with the assistance of his son, in a little time, procured 150. After the defeat of Braddock, Franklin introduced into the assembly a bill for organizing a militia, and had the dexterity to get it passed. In consequence of this act a very respectable militia was formed, and Franklin was appointed colonel of the regiment of Philadelphia, which consisted of 1200 men ; in which capacity he acquitted himself with much propriety, and was of singular service ; though this militia was soon after disbanded by the English ministry.

In 1757, he was sent to England with a petition to the king and council, against the proprietaries, who refused to bear any share in the public expenses and assessments, which he got settled to the satisfaction of the state. After the completion of this business, Franklin remained at the court of Great Britain for some time, as agent to the province of Pennsylvania; and also for those of Massachusetts, Maryland, and Georgia. Soon after this he published his Canada pamphlet, in which he pointed out, in a very forcible manner, the advantages that would result from the conquest of this province from the French. An expedition was accordingly planned, and the command given to General Wolf; the success of which is well known. He now divided his time, indeed, between philosophy and politics, rendering many services to both. Whilst here, he invented the elegant musical instrument called the Armonica, formed of glasses, played upon by the fingers.

In the summer of 1762, he returned to America; on his passage to which he observed the singular effect produced by agitation of a vessel containing oil floating on water : the upper surface of the oil remained smooth and undisturbed, whilst the water was agitated with the utmost commotion. On his return he received the thanks of the Assembly of Pennsylvania, which having annually elected him a member in his absence, he again took his seat in this body, and continued a steady defender of the liberties of the people.

In 1764, by the intrigues of the proprietaries, Franklin lost his seat in the assembly, which he had possessed for 14 years; but he was immediately appointed provincial agent to England, for which country he presently set out.

In 1766, he was examined before the parliament relative to the stamp act; which was soon after repealed. The same year he made a journey into Holland and Germany, and another into France; being every where received with the greatest respect by the literati of all nations.

In 1773, he attracted the public attention by a letter on the duel between Mr. Whately and Mr. Temple, concerning the publication of Governor Hutchinson's letters, declaring that he was the person who had discovered those letters. On the 29th of January, next year, he was examined before the privy-council, on a petition he had presented long before, as agent for Massachusetts Bay, against Mr. Hutchinson ; but this petition being disagreeable to the ministry, it was precipitately rejected, and Dr. Franklin was soon after removed from his office of Post-master General for America. Finding now all efforts to restore harmony between Great Britain and her colonies useless, he returned to America in 1775, just after the commencement of hostilities. Being named one of the delegates of the Continental Congress, he had a principal share in bringing about the revolution and declaration of Independency on the part of the colonies.

In 1776, he was deputed by Congress to Canada, to negotiate with the people of that country, and to persuade them to throw off the British yoke; but the Canadians had been so much disgusted with the hot zeal of the New Englanders, who had burnt some of their chapels, that they refused to listen to the proposals, though enforced by all the arguments Dr. Franklin could make use

of. On his return to Philadelphia, Congress, sensible how much he was esteemed in France, sent him there to put a finishing hand to the private negociation of Mr. Silas Deane; and this important commission was readily accepted by the doctor, though then in the 71st year of his age: the event is well known; a treaty of alliance and commerce was signed between France and America; and M. le Roi asserts, that the doctor had a great share in the transaction, by strongly advising M. Maurepas not to lose a single moment, if he wished to secure the friendship of America, and to detach it from the mother country.

In 1777, he was regularly appointed Plenipotentiary from Congress to the French court; but obtained leave of dismission in 1780. Having at length seen the full accomplishment of his wishes, by the conclusion of the peace in 1783, which gave independence to America, he became desirous of revisiting his native country: he therefore requested to be recalled; and, after repeated solicitations, Mr. Jefferson was appointed in his stead. On the arrival of his successor, he repaired to Havre de Grace, and, crossing the channel, landed at Newport in the Isle of Wight, from whence, after a favourable passage, he arrived safe at Philadelphia, in September 1785. He was received amidst the acclamations of a vast multitude, who flocked from all parts to see him, and who conducted him in triumph to his own house; where in a few days he was visited by the members of Congress, and the principal inhabitants of Philadelphia. He was afterwards twice chosen President of the Assembly of Philadelphia; but his increasing infirmities obliged him to ask permission to retire, and spend the remainder of his life in tranquillity, which was granted in 1788. After this the infirmities of age increased fast upon him; he became more and more afflicted with the gout and the stone till the time of his death, which happened the 17th of April, 1790, about 11 o'clock at night, at 84 years of age, leaving one son, Governor William Franklin, a zealous loyalist, who now resides in London; and a daughter, married to Mr. Richard Beach, merchant, in Philadelphia.

Dr. Franklin was author of many tracts on electricity and other branches of natural philosophy, as well as on political and miscellaneous subjects. He had also many papers inserted in the Philosophical Transactions, from the year 1757 to 1774.

FRANKS. See Letter.

FRAPPING, in naval affairs, the act of crossing and drawing together the several parts of the tackle, or other complication of ropes, which had been already strained to their utmost extent; in this sense it resembles the operation of bracing a drum. The frapping increases tension, and consequently adds to the security acquired by the purchase.

FRAUD. All deceitful practices in defrauding, or endeavouring to defraud, another of his own right, by means of some artful device, contrary to the plain rules of common honesty, are condemned by the common law, and punishable according to the heinousness of the offence.

The distinction laid down, as proper to be attended to in all cases of this kind, is this, that in such impositions or deceits, where common prudence might guard persons from the offence, it is not indictable, but the party is left to his civil remedy; but where false weights or measures are used, or false tokens produced, or such measures taken to defraud, or deceive, as people cannot by any ordinary care or prudence be guarded against, there it is an offence indictable. Persons convicted of obtaining money or goods by false pretences, or sending threatening letters to extort money or goods, may be punished by fine and imprisonment, or by pillory, whipping, or transportation. 30 G. II. c. 24.

FRAXINUS, in botany, English *ash-tree*, a genus of the Polygamia Dioecia class and order. Natural order of Sepiariæ. Jasmineæ, Jussieu. Essential character: hermaphrodite; calyx none, or four-parted; corolla none, or four-petalled; stamens two; pistil one; seed or capsule one, lanceolate. There are four species. The wood of the ash-tree is in great use among several artificers, as wheel-wrights, cart-wrights, carpenters, turners, &c. also for making ploughs, harrows, axle-trees, oars, &c. It is said to be as lasting for building as oak, and often preferred before it; though the timber of the trunk greatly excels that of a bough. Some ash is also so curiously veined, that the cabinet-makers think it equal to ebony, and call it green ebony; so that the woodmen, who light upon such trees, may have for it what they will. The season for felling this tree is from November to

February; for if cut down too early, or too late, it is liable to the worm. The ash is hurtful to corn lands, and therefore should be planted either in hedges or clumps, at about nine or ten feet distance.

FRECKLES, spots of a yellowish colour, of the bigness of a lentile-seed, scattered over the face, neck, and hands. Freckles are either natural, or proceeding accidentally from the jaundice, or the action of the sun upon the part. Heat, or a sudden change of the weather, will often cause the skin to appear of a darker colour than natural, and thereby produce what is called tan, sunburn, &c. which seem to differ only in degree, and usually disappear in winter.

Persons of a fine complexion, and those whose hair is red, are the most subject to freckles, especially in those parts which they expose to the air.

FREE *bench*, in law, is the widow's share of her husband's copyhold, or customary lands, in the nature of dower, which is variable, according to the customs in different places. In some manors it is one third, sometimes half, sometimes the whole during her widowhood, of all the copyhold or customary land which her husband died possessed of. In some places, by custom, she holds them only during her chaste viduity.

FREEHOLD may be in deed or in law. A freehold in deed, is actual seisin of lands or tenements in fee-simple, fee-tail, or for life. A freehold in law, is a right to such lands or tenements before entry or seisure. So there is a seisin in deed, and a seisin in law; a seisin in deed, is when a corporal possession is taken, and a seisin in law, is where lands descend before entry, or where something is done which amounts in law to an actual seisin. Tenant in fee-simple, or fee-tail for life, is said to have a freehold, so called, because it distinguishes it from term of years, chattels upon certain interests, lands in villinage, or customary or copyhold lands. See FEE-SIMPLE. A freehold cannot be conveyed to pass in futuro, for then there would be want of a tenant against whom to bring a præcipe, and therefore, notwithstanding such conveyance, the freehold continues in the vendor; but if livery of seisin be afterwards given, the freehold from thence passes to the vendee. A man is said to be seised of freehold, but to be possessed of other estates, as of copyhold lands, leases for years, or goods and chattels. See ESTATE and FEE-SIMPLE.

FREE *stone*, a whitish stone, dug up in many parts of England, that works like alabaster, but is more hard and durable; being of excellent use in building, &c. It is a kind of grit-stone, but finer sanded, and a smoother stone, and is called free, from its being of such a constitution as to cut freely in any direction: such is the Portland-stone, and the free-stone of Kent.

FREIGHT, is the consideration money agreed to be paid for the use or hire of a ship, or, in a larger sense, the burthen of such ship. The freight is most frequently determined for the whole voyage, without respect to time; sometimes it depends on time; in the former case it is either fixed at a certain sum for the whole cargo, or so much per ton, barrel, bulk, or other weight or measure, or so much per cent. on the value of the cargo. If a certain sum be agreed on for the freight of the ship, it must all be paid, although the ship when measured, should prove smaller, unless the burthen be warranted. If the ship be freighted for transporting cattle or slaves, at so much per head, and some of them die on the passage, freight is only due for such as are delivered alive; if for landing them, it is due for all put on board. When a whole ship is freighted, if the master suffer any goods besides those of the freight to be put on board, he is liable for damages. If the voyage be completed according to the agreement, without any accident, the master has a right to demand the freight before the delivery of the goods; but if such delivery is prevented by negligence, or accidents, the parties will be reciprocally responsible in the following manner: If the merchant should not load the ship within the time agreed on, the master may engage with another, and recover damages. If the merchant recal the ship after she is laden and sailed, he must pay the whole freight; but if he unload before the ship has actually sailed, he will in such case only be responsible for damages. If the merchant load goods which are not lawful to export, and the ship be prevented from proceeding on that account, he must nevertheless pay the freight. If the master be not ready to proceed on the voyage at the time stipulated, the merchant may load the whole, or part of the cargo, on board another ship, and recover damages; but any real casualties will release the master from all damages. If an embargo be laid on the ship before she sail, the charter-party is dissolved, and the

merchant pays the expenses of loading and unloading; but if the embargo be only for a short limited time, the voyage shall be performed when it expires, and neither party is liable for damages. If the master sail to any other port than that agreed on, without necessity, he must sail to the port agreed on at his own expense, and is also liable for any damages in consequence thereof. If a ship be taken by the enemy, and retaken or ransomed, the charter-party continues in force. If the master transfer the goods from his own ship to another, without necessity, and they perish, he is responsible for the full value, and all charges; but if his own ship be in imminent danger, the goods may be put on board another ship, at the risk of the owner. If a ship be freighted out and home, and a sum agreed on for the whole voyage, nothing becomes due until the return of such ship. If a certain sum be specified for the homeward voyage, it is due, although the correspondent abroad should have no goods to send home. A ship was freighted to a particular port and home, a particular freight agreed upon for the homeward voyage, with an option reserved for the correspondent to decline it, unless the ship arrived before a certain day. The master did not go to the port agreed on, and therefore became liable to damages, the obligation being absolute on his part, and conditional only on the part of the freighter. If the goods be damaged without fault of the ship or master, the owner is not obliged to receive them and pay the freight; but he must either receive or abandon the whole; he cannot receive those that are not damaged, and reject the others. If the goods be damaged through the insufficiency of the ship, the master is liable for the same: but if it be owing to stress of weather, he is not accountable. If part of the goods be thrown overboard, or taken by the enemy, the part delivered pays freight; the master is accountable for all the goods received on board by himself and mariners, unless they perish by the act of God or the king's enemies. The master is not liable for leakage of liquors, nor accountable for contents of packages, unless packed in his presence.

FRESCO, in painting, an Italian word, now universally adopted, signifying paintings performed on the walls of palaces and churches. There cannot be a doubt, that this was the original method, in which all large subjects were done, immediately after the discovery of the art of expressing forms and substances, by the judicious disposition of different coloured earths diluted with water. Savages found in a complete state of nature, who knew nothing more than her immediate dictates, have been found covered with colours, collected, and used on their persons by instinct; and some have even demonstrated genius in working the beautiful mantles and helmets formed of feathers of the most vivid tints: one step more would have produced painting on walls, but it was reserved for the ancient Grecians to enlighten and benefit the world by the superior talents they had received and cultivated; it would be vain to enter into an investigation when their attempts arrived to that state of comparative perfection, which produced the delineation of figures on plaster or similar composition; we must, therefore, be satisfied with describing some still extant, of very great antiquity, and mentioning the modern method of using the colours.

It may reasonably be supposed, that the first pictures painted in this way were extremely rude, and probably did not consist of more than two colours, a light one for the ground, and a dark for the outlines; for blending the tints must have been the result of experience, and some degree of freedom. This supposition may be illustrated by referring to the valuable vases brought from Herculaneum, by the late Sir William Hamilton, and now deposited in the British Museum; those, and the paintings found in the same city, were in all probability the performances of Italians, but as the art was then evidently in its infancy, the Greeks might not have excelled their imitators; indeed painting must have been considered by that ingenious people as an art inferior to that of sculpture, which accounts for the superior excellence, and earlier improvements, in the latter.

The appendix to the Abbé Barthelemy's travels in Italy contains several curious remarks on Herculaneum, by Count Caylus and others, and du Theil; the latter supposes that the destruction of this city happened in the year 471. Caylus, on treating upon the ancient paintings discovered, observes, "As to their designing, it is dry, and hardly ever exceeds the idea of a fine statue. The composition is in general cold, for the same reason that the design is dry. In fact, a figure is not grouped, though it be placed with others; and statues in-

tended at first to stand alone, will, with difficulty, enter into composition without some alteration; though the Diana in the Thesus, and the woman with wings in the Telephus, are more contrasted, and have an air of motion.

"The general taste of the composition is remarkable, not only for its resemblance to statues, as I have observed before, but to bas reliefs also. It is clear that the authors had them present to their imagination, and that they had made on their minds a very lively impression.

"The demi-tints are of an olive grey, or of a yellowish or reddish cast, and the shades of red, mixed with black. The draperies, in general, are made with little plaits, formed of light and flexible stuffs, after the style of Roman sculpture." The picture of Telephus is, however, an exception, and seems to lead the author to think, that the artist who performed this piece was superior to those who executed the others.

In the aggregate there are no groupes, harmony, or *claro obscuro*. Each figure stands, as it were, independent, with its own light and shade only, neither receiving reflected light from the next, nor casting shade on it; nor are the shades broken, but done with the same colour as the half tints, and have merely less white; this peculiarity arose from their deficiency in the science of perspective, which reduced the artist to the necessity of making the graduation of distance by the faintness of his colours. "For the rest," adds the Count, "the pictures are done with ease, the touch is bold, and the pencil handled freely, the colouring being sometimes laid on in patches, and sometimes softened down; in a word, the execution is light, and in the same style nearly as we paint the decorations of our theatres, the whole indicating a great practice in the artists."

Thus much is considered necessary, in order to shew that the adoption of many colours in Fresco paintings took place subsequent to 471; like all other arts, it must have been improved by degrees, and it cannot be doubted, that the great masters, whose labours still adorn the numerous churches and palaces in Italy, contributed largely to its perfection, though it is well known that many of their best works have suffered from damps, which it is presumed will prevent their stability wherever it prevails. This circumstance has operated to so great a degree in St. Peter's at Rome, that most of the old pictures have been replaced by others in Mosaic. See Mosaic.

The same cause has prevented the frequent use of Fresco painting in England, except in mansions where a dry air is constantly preserved; the necessity of this precaution is demonstrated at present in the dome of St. Paul's. The manner of performing this description of painting is, to work while the plaster is wet which covers the wall to be decorated; consequently, in the execution of large subjects, the process of plastering must immediately precede the brush of the artist, and only in the proportion he works, that the colours may incorporate with the composition, and that it may not absorb the water which dilutes them, and prevent the free touches intended for effect.

Vitruvius, who calls Fresco painting *udo tectorio*, gives an accurate account of the extreme care which the ancients thought necessary in preparing the stuccoes for the colours, and it must be admitted they succeeded admirably, when we consider how very perfect the remains of their productions now are, after undergoing the sulphurous inhumation of ashes, caused by the eruption of Vesuvius, one thousand three hundred and thirty-seven years past. The moderns, however, conceive that their lime and sand is preferable.

The design intended for a wall should be drawn on paper, or any substance from whence it may be transferred to the wet plaster; the mode of proceeding must afterwards be similar to that practised in painting upon canvas. The colours should be earths, exclusively, diluted with water sufficiently to make them flow freely, but not to decompose the plaster and mix its surface with them; long soft haired brushes should therefore be preferred.

FRESH *suit*, in law, is such a ready and earnest following of an offender, as never ceases, from the time of the offence being committed or discovered, until he be apprehended; and the effect of this, in the pursuit of a felon, is, that the party pursuing shall have his goods again, whereas, otherwise, they are forfeited to the king. Anciently the law was strict in this case, but now the goods are, in all cases, restored to the party.

FRESH, a term used at sea, to signify a strong, but not violent or dangerous, wind: hence, when the gale increases, it is said to freshen. In the plural, the word implies the impetuosity of an ebb-

tide, increasing by heavy rains, and flowing out into the sea, which it often discolours to a considerable distance from the shore, so that the line which divides the two colours may be perceived distinctly for a great length along the coast.

FRET, or FRETTE, in architecture, a kind of knot or ornament, consisting of two lists or small fillets, variously interlaced or interwoven, and running at parallel distances equal to their breadth.

FRET, in heraldry, a bearing composed of six bars, crossed, and variously interlaced.

FRET, in music, signifies a kind of stop on some instruments, particularly bass-viols and lutes. Frets consist of strings tied round the neck of the instrument at certain distances, within which such and such notes are to be found.

FRET *work*, that adorned with frets. It is sometimes used to fill up and enrich flat empty spaces, but is mostly practised in roofs, which are fretted over with plaster-work. The Italians also use fret-works in the mantling of chimneys, with great figures; a cheap piece of magnificence, and as durable almost within doors, as harder matters in the weather.

FRICTION, in mechanics, the rubbing of the parts of engines and machines against each other, by which means a great part of their effect is destroyed.

It is hardly possible to lay down general rules concerning the quantity of friction, since it depends upon a multiplicity of circumstances, as the structure, firmness, elasticity, &c. of the bodies rubbing against each other. Some authors make friction upon an horizontal plane, equal to one-third of the weight to be moved; whilst others have found it to be considerably less. Two objects must, however, be observed, *viz.* the loss of power which is occasioned by it, and the contrivances which have been made, and are in use, for the purpose of diminishing its effects. A body of a horizontal plane should be capable of being moved by the application of the least force; but this is not the case, and the principal causes, which render a greater or less quantity of force necessary for it, are, 1, the roughness of the contiguous surfaces; 2, the irregularity of the figure, which arises either from the imperfect workmanship, or from the pressure of one body from the other; 3, an adhesion, or attraction, which is more or less powerful, according to the nature of the bodies in question; and 4, the interposition of extraneous bodies, such as moisture, dust, &c.

Innumerable experiments have been made for the purpose of determining the quantity of obstruction, or of friction, which is produced in particular circumstances. But the results of apparently similar experiments, which have been made by different experimenters, do not agree; nor is it likely they should, since the least difference of smoothness or polish, or of hardness, or, in short, of any of the various concurring circumstances, produces a different result. Hence no certain and determinate rules can be laid down with respect to the subject of friction. Mr. Vince, who has done much on this subject, infers, 1, That friction is an uniformly retarding force in hard bodies, not subject to alteration by the velocity, except when the body is covered with cloth, woollen, &c. and in this case the friction increases a little with the velocity. 2, Friction increases in a less ratio than the quantity of matter or weight of the body. This increase, however, is different for the different bodies, more or less, nor is it yet sufficiently known for any one body, what proportion the increase of friction bears to the increase of weight. 3, The smallest surface has the least friction, the weight being the same. But the ratio of the friction to the surface is not yet accurately known. Mr. Vince's experiments consisted in determining how far the sliding bodies would be drawn in given times, by a weight hanging freely over a pulley. This method would both show him if the friction was a constant retarding force, and the other conclusions above stated. For as the spaces described by any constant force, in given times, are as the squares of the times, and as the weight drawing the body is a constant force, if the friction, which acts in opposition to the weight, should also be a constant force, then their difference, or the force by which the body is urged, will also be constant; in which case the spaces described ought to be as the squares of the times, which happened accordingly in the experiments. The friction, *cæteris paribus*, increases with the weight of the superincumbent body, and almost in the same proportion. The friction, or obstruction which arises from the bending of ropes about machines, is influenced by a variety of circumstances, such as their peculiar quality, the temperature of the atmosphere, and the diameter, or curvature of the surface to which they are to be adapted. But when other

circumstances remain the same, the difficulty of bending a rope increases with the square of its diameter, as also with its tension; and it decreases according as the radius of the curvature of the body to which it is adapted increases. Of the simple mechanical powers, the lever is the least subject to friction. In a wheel, the friction upon the axis is as the weight that lies upon it, as the diameter of the axis, and as the velocity of the motion. But upon the whole this sort of friction is not very great, provided the machine is well executed. In common pullies, especially those of a small size, the friction is very great. It increases in proportion as the diameter of the axis increases, as the velocity increases, and as the diameter of the pully decreases. With a moveable tackle or block of 5 pullies, a power of 150 pounds will barely be able to draw up a weight of 500 pounds. The screw is subject to a great deal of friction; so much so, that the power which must be applied to it, in order to produce a given effect, is at least double that which is given by the calculation, independent of friction. But the degree of friction in the screw is influenced considerably by the nature of the construction, for much of it is owing to the tightness of the screw, to the distance between its threads, and to the shape of the threads; the square threads producing, upon the whole, less friction than those which are sharp. The friction which attends the use of the wedge exceeds, in general, that of any other simple mechanical power. Its quantity depends so much upon the nature of the body upon which the wedge acts, besides other circumstances, that it is impossible to give even an approximate estimate of it. The friction of mechanical engines not only diminishes the effect, or, which is the same thing, occasions a loss of power, but is attended with the corrosion and wear of the principal parts of the machine, besides producing a considerable degree of heat, and even actual fire; it is, therefore, of great importance in mechanics to contrive means capable of diminishing, if not of quite removing, the effects of friction.

The methods of obtaining the important object of diminishing the friction are of two sorts, *viz.* either by the interposition of particular unctuous or oily substances between the contiguous moving parts, or by particular mechanical contrivances. Olive-oil is the best, and perhaps the only substance that can be used in small works, as in watches and clocks, when metal works against metal. But in large works the oil is liable to drain off, unless some method is adopted to confine it. Therefore, for large works, tallow is mostly used, or grease of any sort, which is useful for metal, as well as for wood. In the last case tar is also frequently used. The mechanical contrivances which have been made, and are in use, for the purpose of diminishing the effects of friction, consist either in avoiding the contact of such bodies as produce much friction, or in the interposition of rollers, *viz.* cylindrical bodies, between the moving parts of machines, or between moving bodies in general. Such cylinders derive, from their various size and application, the different names of rollers, friction wheels, and friction rollers. Thus in mill-work, and other large machines, the wooden axis of large wheels terminate in iron gudgeons, which turn in wood, or more frequently in iron or brass, which construction produces less friction than the turning of wood in wood. In the finest sort of watch-work the holes are jewelled, *viz.* many of the pivots of the wheels, &c. move in holes made in rubies, or topazes, or other hard stone, which, when well finished, are not liable to wear, nor do they require much oil. In order to understand the nature of rollers, and the advantage with which their use is attended, it must be considered, that when a body is dragged over the surface of another body, the inequalities of the surfaces of both bodies meet, and oppose each other, which is the principal cause of the friction or obstruction; but when one body, such as a cask, a cylinder, or a ball, is rolled upon another body, the surface of the roller is not rubbed against the other body, but is only successively applied to, or laid on, the other, and is then successively lifted up from it. Therefore, in rolling, the principal cause of friction is avoided, besides other advantages: hence a body may be rolled upon another body, when the shape admits of it, with incomparably less exertion than that which is required to drag it over the surface of that other body. In fact, we commonly see large pieces of timber, and enormous blocks of stone, moved upon rollers that are laid between them and the ground with ease and safety, when it would be almost impossible to move them otherwise.

Friction, is a term made use of in medicine, and implies the act of rubbing a diseased part with oils, or other substances. Friction is also applied to the

rubbing the human body with a flesh-brush, flannel, &c.; but the most important purpose of this kind of friction is for the introduction of mercury into the habit by means of the skin, instead of the mouth.

FRIEND, or *quaker*. A society of dissenters from the church of England obtained the latter appellation in the middle of the seventeenth century; the former they had before applied, and continue to apply, to themselves. The first preacher of this society was George Fox, a man of humble birth, and illiterate. The undertaking to which he considered himself called, that of promulgating a more simple and spiritual form of Christianity than any of those which prevailed, and of directing the attention of Christians to immediate revelation, required little more reading than that of the Bible. A constant reference to the scriptures, with great zeal, courage, and perseverance, in preaching and suffering, did more than literature could have done to spread his doctrine among the middle and lower classes. The most prominent feature in the Friends' view of Christianity, is this: seeing no man knoweth the Father, but the Son, and he to whomsoever the Son will reveal him; and seeing the revelation of the Son is in and by the Spirit; therefore the testimony of the Spirit is that alone by which the true knowledge of God is revealed. In this doctrine they agree, in substance, with the church of England, and all others who acknowledge the efficacy of grace. For in whatever way this is afforded to Christians, it is powerfully given to know and to do the will of God; and the communication of grace may be termed, in strict consistency with the sense of the NewTestament, a revelation of Christ in the Spirit. The Friends receive the Holy Scriptures as having proceeded from the revelations of the Holy Spirit; they account them the secondary rule for Christians, subordinate to the word, and therefore not the word of God. According to these they profess their belief in one God, as Father, Word, and Holy Spirit; in one Mediator, the Word made flesh, Jesus Christ; in the conception, birth, life, miracles, death, resurrection, and ascension of Jesus; and in the remission of sins thereby purchased for the whole world of fallen mankind. Christ's redemption they believe to be perfected in us by his second coming in spirit; in which they who obey him are, through the obedience of faith, restored from their state of alienation, and reconciled to God. They affirm, that for this end there is given to every man a measure of the light of Christ, (called, by their early preachers, the light within) a manifestation of the Spirit to profit withal; which discovers sin, reproves for it, leads out of it, and, if not resisted, will save from it, and lead on the Christian to perfection. In public worship, they profess to wait on God in this gift, in order to have their conditions made manifest, in silence and retirement of mind. They look for an extraordinary motion of it for social worship, and considering the qualification of a minister as a further gift which God confers, and of which the church ought to judge in the same spirit, they do not limit its exercise to any description of persons. They suffer some inconvenience hereby, as they acknowledge; but they prefer bearing this to the establishing of any form of worship, save the fore-mentioned waiting in silence. They do not baptize formally, or use the sign of the communion; they say, the one has ceased as to obligation, and that the true administration of the other is by the spirit alone. They deem it unlawful for Christians to swear at all; and their affirmation in civil causes is made legal instead of an oath. They refuse to "learn war, or to lift up the sword," as well as to contribute directly to military proceedings. Yet, as they inculcate implicit submission, actively or passively, to Cæsar, they neither resist nor evade the legal appropriation of their substance by him, as well to these as to ecclesiastical purposes. Against the claims of the clergy, as well as many other things apparently lawful, they say, in their phraseology, they have a testimony to bear. Some peculiarities mark them out from their fellow-citizens. Simplicity in dress, in some instances nearly amounting to an adherence to their original, though not prescribed, costume; simplicity of language, thou to one person, and without compliments; simplicity in their manners of living; the non-observance of fasts and feasts; the rejection of those which they call the unchristian names of days and months; and the renunciation of the theatres and other promiscuous amusements, gaming, and the usual outward signs of mourning and rejoicing, may be considered as their *shibboleth.* They marry among themselves by a ceremony, or contract, religiously conducted, and bury their dead in the most simple manner. They maintain their poor, and enforce their own rules, by means of an excellent system of discipline, founded by G. Fox. They receive approved applicants into

their society by an act of monthly meeting, or particular congregation, and without subscription of articles. They disown, in the same manner, after repeated admonition, not officially only, but actually extended, to offenders against morality, or their peculiar rules.

FRIEZE, FREEZE, or FRIZE, in architecture, a large flat face, or member, separating the architrave from the cornice, being that part of the entablature between the architrave and cornice. See ARCHITECTURE.

FRIGATE, among seamen, a ship of war, light built, and that is a good sailer. A frigate has commonly two decks, whence that called a light frigate is a frigate with only one deck. These vessels mount from 20 to 44 guns, and make capital cruizers. Merchantmen are said to be frigate built, when the disposition of the decks have a descent of four or five steps from the quarter-deck and forecastle into the waist, in contradistinction to those whose decks are on a continued line for the whole length of the ship, which are called galley-built. Formerly the name of frigate was only known in the Mediterranean, and applied to a kind of long vessels, navigated in that sea with sails and oars. Our countrymen were the first who appeared on the ocean with those ships, and equipped them for war as well as commerce.

FRINGILLA, the *finch*, in natural history, a genus of birds of the order Passeres. Generic character: bill perfectly conic; slender towards the end, and extremely pointed. Many of this tribe are truly admirable, both for the elegance of their plumage, and the vivacity and melody of their song. Latham enumerates 96 species, and Gmelin 111; of which we shall notice the following: F. domestica, or the house sparrow of Europe, is never found remote from human habitations; but, following the society of man, builds under the roofs of houses, and in the holes of walls, and will frequently expel the martin from its nest, to save itself the trouble of preparing one of its own. It breeds generally three times in a year. By the destruction of caterpillars, these birds are eminently serviceable; but their favourite food is grain, to procure which they are constant attendants at the barn-door, and notwithstanding every effort to scare them, will dare every danger to partake of the repasts of the poultry and pigeons. They are particularly sagacious as well as daring, and can, with great difficulty only, be decoyed by traps. Their sounds are harsh and grating, their dispositions irascible, and their manners intrusive. F. cœlebs, or the chaffinch, is found in England throughout the year, and builds its nest with extreme care and neatness, lining it with hair, wool, and feathers. It is sprightly in its movements, and beautiful in its plumage; but can boast no peculiar powers of melody. The most singular circumstance attending this species of birds is, that, in some countries, the males remain all the year round, while the females are migratory to the south, returning in the spring to their former habitations and companions. Flocks, composed only of females, have occasionally been seen in Hampshire. This circumstance is not peculiar to these birds, but affects equally some other descriptions. It is in itself, however, not a little curious, and merits attention. F. carduelis, or goldfinch, is common in Europe and to be found, though by no means so frequently, in Africa and Asia. It breeds twice a year, and feeds principally on seeds, and especially those of thistles, near which it prefers building its nest, which is formed with great compactness and skill. It begins to sing in April, and continues its song till the period of breeding is past. In confinement, however, it will sing for the greater part of the year. These birds are universally admired for the brilliancy of their plumage, and the melody of their sounds; and they possess, moreover, a docility, which renders them particularly interesting, learning, with ease, a variety of ingenious movements and exercises. They are long lived, and have been known to survive the age of twenty years. Buffon mentions the case of a goldfinch which suddenly became black, and, after continuing so for eight months, resumed its former sprightly and elegant colouring: this revolution was repeated at two subsequent periods. (See Aves, Plate VI. fig. 6.) F. spinus, or the siskin, is found in various parts of Europe, generally migratory, but at irregular periods, and in very unequal numbers; the larger flights being supposed by some naturalists to occur only once in several years. It hides its nest with particular caution: and though vast numbers are to be seen on the borders of the Danube, which have not lost their original feathers, their nests have been sought, it is said, in the neighbourhood with great assiduity, but in very few instances with success. It is nearly as tractable as the goldfinch, has great richness and variety of notes, and extraordinary power in imitating sounds. F. canaria, or canary finch. These birds

constitute, to some little extent, an article of commerce, being exported from the Tyrol in considerable numbers every year to various other parts of Europe. Buffon enumerates no fewer than 29 varieties, and devotes 50 pages of his celebrated work to an interesting detail of their manners, habits, and song. They are bred and reared in England in aviaries with great facility; and the fidelity of their attachments, and delicacy of their attentions, their extreme neatness, parental affection, and animated and almost incessant music, constitute a source of pure and exquisite entertainment to all the admirers of artless and interesting nature. F. linaria, or the linnet, is to be met with in every part of Europe and America, and is particularly common in England, where it builds, generally in thorns and furze bushes, and breeds twice in the year. Linnets feed on various seeds; but particularly relish those of the flax plant, from the Latin name for which (*linum*) they probably derive their name. They can be taught the notes of various other birds, and even to utter words with very distinct enunciation; but their natural song, expressive of tranquillity, and rapture, and poured out in a strain of richly varied melody, is infinitely superior to these unmeaning and elaborate articulations. Mr. Wilson enumerates 17 species as natives of the United States. For the red pole and the mountain-sparrow, see Aves, Plate VI. fig. 7 and 8.

FRIT, in the glass manufacture, the matter or ingredients whereof glass is to be made, when they have been calcined or baked in a furnace; or it is the calcined matter to be run into glass. See Glass.

FRITILLARIA, in botany, *imperial fritillary*, or *crown imperial*, a genus of the Hexandria Monogynia class and order. Natural order of Coronariæ. Lilia, Jussieu. There are five species, with many varieties.

FRIZING *of cloth*, a term in the woollen manufacture, applied to the forming of the nap of cloth, or stuff, into a number of little hard burrs or prominences, covering almost the whole grouud thereof. Some cloths are only frized on the back side, as black cloths; others on the right side, as coloured and mixed cloths, rateens, bays, frizes, &c. Frizing may be performed two ways; one with the hand, that is, by means of two workmen, who conduct a kind of plank that serves for a frizing instrument.

The other way is by a mill, worked either by water, or a horse, or sometimes by men. This latter is esteemed the better way of frizing, by reason, the motion being uniform and regular, the little knobs of the frizing are formed more equably and regularly. The structure of this useful machine is as follows:

The three principal parts are the frizer or crisper, the frizing-table, and the drawer or beam. The two first are two equal planks, or boards, each about ten feet long, and fifteen inches broad, differing only in this, that the frizing-table is lined or covered with a kind of coarse woollen stuff, of a rough sturdy nap; and the frizer is incrustated with a kind of cement composed of glue, gum arabic, and a yellow sand, with a little aquavitæ, or urine. The beam, or drawer, thus called because it draws the stuff from between the frizer and the frizing-table, is a wooden roller, beset all over with little, fine, short points, or ends of wire, like those of cards used in carding of wool.

The disposition and use of the machine is thus: the table stands immoveable, and bears or sustains the cloth to be frized, which is laid with that side uppermost on which the nap is to be raised: over the table is placed the frizer, at such a distance from it as to give room for the stuff to be passed between them, so that the frizer, having a very slow semicircular motion, meeting the long hairs or naps of the cloth, twists and rolls them into little knobs or burrs, while, at the same time, the drawer, which is continually turning, draws away the stuff from under the frizer, and winds it over its own points.

All that the workman has to do while the machine is going is, to stretch the stuff on the table, as fast as the drawer takes it off; and from time to time to take off the stuff from the points of the drawer. The design of having the frizing-table lined with stuff of a short, stiff, stubby nap, is, that it may detain the cloth between the table and the frizer long enough for the grain to be formed, that the drawer may not take it away too readily, which must otherwise be the case, as it is not held by any thing at the other end.

FROG. See Rana.

FRONDESCENTIA, in botany, a term expressive of the precise time of the year and month, in which each species of plants unfolds its first leaves. All plants produce new leaves every year; but all do not renew them at the same time. Among woody plants, the elder, and most of the honey-suckles; among perennial herbs, crocus and tulip are the first that push or expand their leaves. The time of sowing the seed decides with respect to

annuals. The oak and ash are constantly the latest in pushing their leaves; the greatest number unfold them in spring; the mosses and firs in winter. These striking differences, with respect to so capital a circumstance in plants as that of unfolding their leaves, seem to indicate that each species of plant has a temperature proper or peculiar to itself, and requires a certain degree of heat to extricate the leaves from their buds, and produce the appearance in question. This temperature, however, is not so constant, as, to a superficial observer, it may appear to be. Among plants of the same species, there are some more early than others; whether that circumstanue depends, as it most commonly does, on the nature of the plants, or is owing to differences in heat, exposure, and soil. In general, it may be affirmed, that small and young trees are always earlier than larger or old ones. See Germination, and Milne's Bot. Dict.

FROST, such a state of the atmosphere as causes the congelation or freezing of water or other fluids into ice. In the more northern parts of the world, even solid bodies are affected by frost, though this is only or chiefly in consequence of the moisture they contain, which being frozen into ice, and so expanding as water is known to do when frozen, it bursts, and rends any thing in which it is contained, as plants, trees, stones, and large rocks. Many fluids expand by frost, as water, which expands about one-tenth part, for which reason ice floats in water; but others again contract, as quicksilver, and thence frozen quicksilver sinks in the fluid metal.

Frost, being derived from the atmosphere, naturally proceeds from the upper parts of bodies downwards, as the water and the earth: so, the longer a frost is continued, the thicker the ice becomes upon the water in ponds, and the deeper into the earth the ground is frozen. In about 16 or 17 days frost, Mr. Boyle found it had penetrated 14 inches into the ground. At Moscow, in a hard season, the frost will penetrate two feet deep into the ground: and Captain James found it penetrated 10 feet deep in Charlton Island, and the water in the same island was frozen to the depth of six feet. Sheffer assures us, that in Sweden the frost pierces two cubits, or Swedish ells, into the earth, and turns what moisture is found there into a whitish substance, like ice; and standing water to three ells or more. The same author also mentions sudden cracks or rifts in the ice of the lakes of Sweden, nine or ten feet deep, and many leagues long; the rupture being made with a noise not less loud than if many guns were discharged together. By such means, however, the fishes are furnished with air; so that they are rarely found dead.

The natural history of frosts furnish very extraordinary effects. The trees are often scorched and burnt up, as with the most excessive heat, in consequence of the separation of water from the air, which is therefore very drying In the great frost in 1683, the trunks of oak, ash, walnut, &c. were miserably split and cleft, so that they might be seen through, and the cracks often attended with dreadful noises like the explosion of fire-arms. Philos. Trans. Number 165.

The close of the year 1708, and the beginning of 1709, were remarkable, throughout the greatest part of Europe, for a severe frost. Dr. Derham says it was the greatest in degree, if not the most universal, in the memory of man; extending through most parts of Europe, though scarcely felt in Scotland or Ireland.

In very cold countries, meat may be preserved by the frost six or seven months, and prove tolerably good eating. See Captain Middleton's observations made in Hudson's Bay, in the Philos. Trans. Number 465, sect. 2.

In that climate the frost seems never out of the ground, it having been found hard frozen in the two summer months. Brandy and spirit, set out in the open air. freeze to solid ice in three or four hours.

Lakes and standing waters, not above 10 or 12 feet deep, are frozen to the ground in winter, and all their fish perish. But in rivers, where the current of the tide is strong, the ice does not reach so deep, and the fish are preserved. Id. ib.

Some remarkable instances of frost in Europe, and chiefly in England, are recorded as below; in the year

220 Frost in Britain that lasted five months.

250 The Thames frozen nine weeks.

291 Most rivers in Britain frozen six weeks.

359 Severe frost in Scotland for 14 weeks.

508 The rivers in Britain frozen for two months.

558 The Danube quite frozen over.

695 Thames frozen six weeks; booths built on it.

759 Frost from Oct. 1, till Feb. 26, 760.

827 Frost in England for nine weeks.
859 Carriages used on the Adriatic Sea.
908 Most rivers in England frozen two months.
923 The Thames frozen 13 weeks.
987 Frost lasted 120 days: began December 22.
998 The Thames frozen five weeks.
1035 Severe frost on June 24: the corn and fruits destroyed.
1063 The Thames frozen fourteen weeks.
1076 Frost in England from November till April.
1114 Several wooden bridges carried away by ice.
1205 Frost in England from January 14, till March 22.
1407 Frost that lasted 15 weeks.
1434 From Novem. 24, till Feb. 10, Thames frozen down to Gravesend.
1683 Frost for thirteen weeks.
1708-9 Severe frost for many weeks.
1715 The same for many weeks.
1739 One for nine weeks: began December 24.
1742 Severe frost for many weeks.
1747 Severe frost in Russia.
1751 Severe one in England.
1760 The same in Germany.
1776 The same in England.
1788 The Thames frozen below bridge; booths on it.
1794 Hard frost of many weeks. Ther. at London, mostly at 20 below 0 of Fahrenheit.

Hoar frost, is the dew frozen or congealed early in cold mornings; chiefly in autumn. Though many Cartesians will have it formed of a cloud; and either congealed in the cloud, and so let fall, or ready to be congealed as soon as it arrives at the earth.

Hoar frost, M. Regius observes, consists of an assemblage of little parcels of ice crystals, which are of various figures, according to the different disposition of the vapours, when met and condensed by the cold.

FROTH *spit*, or Cuckow *spit*, a name given to a white froth, or spume, very common in the spring and first months of the summer, on the stems of certain plants; it includes and defends the larva of certain species of Cicada, and from the pores of which it is secreted at pleasure. See Cicada.

FRUCTESCENTIA, in botany, comprehends the precise time, in which, after the fall of the flowers, the fruits arrive at maturity, and disperse their seeds. In general, plants which flower in spring ripen their fruits in summer, as rye; those which flower in summer have their fruits ripe in autumn, as the vine; the fruit of autumnal flowers ripen in winter, or the following spring, if kept in a stove or otherwise defended from excessive frosts. The time in which plants ripen their fruit, combined with that in which they germinate and unfold their leaves, gives the entire space or duration of their life, which, in the same species, is proportionally short or long, according to the greater or less intensity of heat of the climate in which they are cultivated. In general, it appears, that, if the heat is equal and uninterrupted, the time betwixt the germinating or sprouting and flowering of annual plants is equal to the interval betwixt their flowering and the maturation of the fruits, or even the total destruction of the whole plant. In very hot climates, an annual plant generally lives as long before as after flowering. But in temperate climates, as France and England, plants which rise in spring, and flower before the month of June, live a little longer before than after flowering; such as flower in summer, as barley and oats, which flower in June, live as long before as after; while the later plants, which do not rise till autumn, live longer after flowering than before. These observations apply chiefly to herbaceous annuals. See Milne's Botanical Dictionary.

FRUSTUM, in mathematics, a part of some solid body separated from the rest.

The frustum of a cone is the part that remains, when the top is cut off by a plane parallel to the base; and is otherwise called a truncated cone. The frustum of a pyramid is also what remains, after the top is cut off by a plane parallel to its base. To find the solid content of the frustum of a cone, pyramid, &c. the base being of any figure whatever: add the areas of the two ends and the mean proportional between them together, then one-third of that sum will be the mean area, or the area of an equal prism, of the same altitude with the frustum; and consequently, that mean area multiplied by the height of the frustum will give the solid content for the product:

If $A =$ area of the greater end
$a =$ ——— lesser end
$h =$ height: then

$$\frac{A + a + \sqrt{Aa}}{3} \times h = \text{the solidity.}$$

The frustum of a globe or sphere is any part thereof cut off by a plane, the solid contents of which may be found by this rule. To three times the square of the semi-diameter of the base, add the square of its height; then multiplying that sum by the height, and this product multiplied by 5236, gives the solidity of the frustum. A frustum, or portion of any solid, generated by the revolution of any conic section upon its axis, and terminated by any two parallel planes, may be thus compared to a cylinder of the same altitude, and whose base is equal to the middle section of the frustum made by a parallel plane. 1. The difference between such frustum and cylinder is always the same in different parts of the same or of similar solids, when the inclination of the planes to the axis and the altitude of the frustum are given. 2. In the parabolic conoid, this difference vanishes; the frustum being always equal to a cylinder of the same height, upon the section of the conoid that bisects the altitude of the frustum, and is parallel to its bases. 3. In the sphere, the frustum is always less than the cylinder, by one fourth part of a right angled cone of the same height with the frustum; or by one half of a sphere, of a diameter equal to that height: and this difference is always the same in all spheres whatever, when the altitude of the frustum is given. 4. In the cone, the frustum always exceeds the cylinder, by one fourth part of the content of a similar cone, that has the same height with the frustum.

As a general theorem: in the frustum of any solid, generated by the revolution of any conic section about its axis: if to the sum of the two ends be added four times the middle section, then the last sum divided by six will be the mean area, and being drawn into the altitude of the solid will produce the content: That is, A and a being the areas of the ends, M equal the middle section, then we have

$$\frac{A + a + 4M}{6} \times h = \text{solid content.}$$

This theorem holds good for complete solids as well as frustums, whether right or oblique, and not only of the solids generated from the conic sections, but also of all pyramids, cones, and in short of any solid, whose parallel sections are similar figures.

FUCHSIA, in botany, so called in honour of Leonard Fuchs, a famous German botanist, a genus of the Octandria Monogynia class and order. Natural order of Onagræ, Jussieu. Essential character: calyx one-leafed, coloured, bearing the corolla, very large; petals four, small; berry inferior, four-celled, with many seeds. There are five species.

FUCUS, in botany, a genus of the Cryptogamia Algæ. Generic character: male vesicles smooth, hollow, with villose hairs within, interwoven: female, vesicles smooth, filled with jelly, sprinkled with immersed grains, prominent at the tip. Seeds solitary. This genus comprehends most of those plants which are commonly called sea-weeds: more than seventy species are enumerated; they may all be used to manure land, or burnt for alkali. Some of the species are eaten, either fresh out of the sea, or boiled tender, with butter, pepper, &c. If the F. saccharinus is washed in spring water, and then hung up in a warm place, a substance like sugar exudes from it.

FUEL. Dr. Black divides fuels into five classes; the first comprehends the fluid inflammable bodies; the second, peat or turf; the third, charcoal of wood; the fourth, pit-coal charred; and the fifth, wood, or pit-coal, in a crude state, and capable of yielding a copious and bright flame.

The fluid inflammables are considered as distinct from the solid, on this account, that they are capable of burning upon a wick, and become in this way the most manageable sources of heat; though, on account of their price, they are never employed for producing it in great quantities; and are only used when a gentle degree, or a small quantity of heat, is sufficient. The species which belong to this class are alcohol and different oils.

The first of these, alcohol, when pure and free of water, is as convenient and manageable a fuel for producing moderate or gentle heats as can be desired. Its flame is perfectly clean, and free from any kind of soot; it can easily be made to burn slower or faster, and to produce less or more heat, by changing the size or number of the wicks upon which it burns; for as long as these are fed with spirit, in a proper manner, they continue to yield flame of precisely the same strength.

The cotton, or other materials, of which the wick is composed, is not scorched or consumed in the least, because the spirit with which it is constantly soaked is incapable of becoming hotter than 174° Fahrenheit, which is considerably below the heat of boiling water. It is only the vapour that arises from it which is hotter, and this too only in its outer parts, that are most remote from the wick, and where only the combustion is going on, in consequence of communication and contact with the air. At the same time, as the alcohol is totally volatile, it does not leave any fixed matter, which, by being accumulated on the wick, might render it foul and fill up its pores. The wick, therefore, continues to imbibe the spirit as freely, after some time, as it did at the first. These are the qualities of alcohol as a fuel. But these qualities belong only to a spirit that is very pure. If, on the contrary, it be weak, and contain water, the water, being less volatile, does not evaporate so fast from the wick as the more spirituous part; and the wick becomes, after some time, so much soaked with water, that it does not imbibe the spirit properly. The flame becomes much weaker, or is altogether extinguished. When alcohol is used as a fuel, therefore, it ought to be made as strong, or free from water, as possible.

Oil, although fluid like spirit of wine, and capable of burning in a similar manner, is not so convenient in many respects. It is disposed to emit soot; and this applying itself to the bottom of the vessel exposed to it, and increasing in thickness, forms, by degrees, a foft and spongy medium, through which heat is not so freely and quickly transmitted. This was observed by Muschenbroeck, in his experiments upon the expansions of metalline rods heated by lamps. It is true we can prevent this entirely by using very small wicks, and increasing the number, if necessary, to produce the heat required. Or we may employ one of those lamps, in which a stream of air is allowed to rise through the middle of the flame, or to pass over its surface with such velocity as to produce a more complete inflammation than ordinary. But we shall be as much embarrassed in another way, for the oils commonly used, being capable of assuming a heat greatly above that of boiling water, scorch and burn the wick, and change its texture, so that it does not imbibe the oil so fast as before. Some have attempted a remedy, by making the wick of incombustible materials, as asbestos, or wire; but still, as the oil does not totally evaporate, but leaves a small quantity of gross fixed carbonaceous matter, this, constantly accumulating, clogs the wick to such a degree, that the oil cannot ascend, the flames become weaker, and, in some cases, are entirely extinguished. There is, however, a difference among the different oils in this respect; some being more totally volatile than others. But the best are troublesome in this way, and the only remedy is, to change the wicks often, though we can hardly do this and be sure of keeping always an equal flame.

The second kind of fuel mentioned, peat, is so spongy, that, compared with the more solid fuels, it is unfit to be employed for producing very strong heats. It is too bulky for this; we cannot put into a furnace, at a time, a quantity that corresponds with the quick consumption that must necessarily go on when the heat is violent. There is, no doubt, a great difference in this respect among different kinds of this fuel; but this is the general character of it. However, when we desire to produce and keep up, by means of cheap fuel, an extremely mild gentle heat, we can hardly use any thing better than peat. But it is best to have it previously charred, that is scorched, or burnt to black coal. The advantages gained by charring have been already explained. When prepared for use in that manner, it is capable of being made to burn more slowly and gently, or will bear, without being extinguished altogether, a greater diminution of the quantity of air with which it is supplied, than any other of the solid fuels. Dr. Boerhaave found it extremely convenient and manageable in his Furnus Studiosorum.

The next fuel in order is the charcoal of wood. This is prepared by piling up billets of wood into a pyramidal heap, with several spiracles, or flues, formed through the pile. Chips and brushwood are put into those below, and the whole is so constructed, that, when kindled, it kindles almost over the whole pile in a very short time. It would burst out into a blaze, and be quickly consumed to ashes, were it not covered all over with earth or clay, beaten close, leaving openings at all the spiracles. These are carefully watched; and whenever the white watery smoke is observed to be succeeded by thin blue and transparent smoke, the hole is immediately stopped; this

being the indication of all the watery vapour being gone, and the burning of the true coaly matter commencing. Thus is a pretty strong red heat raised through the whole mass, and all the volatile matters are dissipated by it, and nothing now remains but the charcoal. The holes being all stopped in succession, as this change of the smoke is observed, the fire goes out for want of air. The pile is now allowed to cool This requires many days; for, charcoal being a very bad conductor of heat, the pile long remains red hot in the centre, and, if opened in this state, would instantly burn with fury.

Small quantities may be procured at any time, by burning wood in close vessels. Little pieces may be very finely prepared, at any time, by plunging the wood in lead melted and red hot.

This is the chief fuel used by the chemists abroad, and has many good properties. It kindles quickly, emits few watery or other vapours while burning, and when consumed leaves few ashes, and those very light. They are, therefore, easily blown away, so that the fire continues open, or pervious to the current of air which must pass through it to keep it burning. This sort of fuel, too, is capable of producing as intense a heat as can be obtained by any; but in those violent heats it is quickly consumed, and needs to be frequently supplied.

Fossil coals charred, called cinders, or coaks, have, in many respects, the same properties as charcoal of wood; as kindling more readily in furnaces than when they are not charred, and not emitting watery, or other gross smoke, while they burn. This sort of charcoal is even greatly superior to the other in some properties.

It is a much stronger fuel, or contains the combustible matter in greater quantity, or in a more condensed state. It is, therefore, consumed much more slowly on all occasions, and particularly when employed for producing intense melting heats. The only inconveniences that attend it are, that, as it consumes, it leaves much more ashes than the other, and these much heavier too, which are, therefore, liable to collect in such quantity as to obstruct the free passage of air through the fire; and further, that when the heat is very intense, these ashes are disposed to melt or vitrify into a tenacious drossy substance, which clogs the grate, the sides of the furnace, and the vessels. This last inconvenience is only troublesome, however, when the heat required is very intense. In ordinary heat the ashes do not melt, and though they are more copious and heavy than those of charcoal of wood, they seldom choke up the fire considerably, unless the bars of the grate be too close together.

This fuel, therefore, is preferable, in most cases, to the charcoal of wood, on account of its burning much longer, or giving much more heat before it is consumed. The heat produced by equal quantities, by weight, of pit-coal, wood-charcoal, and wood itself, are nearly in proportion of 5, 4, and 3. The reason why both these kinds of charcoal are preferred, on most occasions, in experimental chemistry, to the crude wood, or fossil coal, from which they are produced, is, that the crude fuels are deprived, by charring, of a considerable quantity of water, and some other volatile principles, which are evaporated during the process of charring, in the form of sooty smoke or flame. These volatile parts, while they remain in the fuel, make it unfit (or less fit) for many purposes in chemistry. For, besides obstructing the vents with sooty matter, they require much heat to evaporate them; and therefore, the heat of the furnace, in which they are burnt, is much diminished and wasted by every addition of fresh fuel, until the fresh fuel is completely inflamed, and restores the heat to its former strength.

But these great and sudden variations of the heat of a furnace are quite inconvenient in most chemical processes. In the greater number of chemical operations, therefore, it is much more convenient to use charred fuel, than the same fuel in its natural state.

There are, at the same time, some kinds of fossil coal, which are exceptions to what has now been delivered in general. We meet with some of them that leave a smaller proportion of ashes than others, and the ashes of some are not so liable to melt in violent heats. There is one species too, such as the Kilkenny coal of Ireland, and which occurs likewise in some parts of this country, that does not contain any sensible quantity of water, or other such volatile principles. But this may be called a sort of native charcoal. It has the appearance of ordinary coal, but, when thrown into the fire, does not emit smoke or soot. It merely becomes red, gives a subtile blue flame, and consumes like charcoal; only it lasts surprisingly long, or continues to gives heat for a very long time before it

is totally consumed. But it cannot be made to burn so as to produce a gentle heat. If not in considerable quantity, and violently heated, it is soon extinguished.

In using this kind of fuel, it is proper to be on our guard against the dangerous nature of the burnt air which arises from charcoal of all kinds. Charcoal burns without visible smoke. The air arising from it appears to the eye as pure and as clear as common air. Hence it is much used abroad by those who are studious of neatness and cleanliness in their apartments. But this very circumstance should make us more watchful against its effects, which may prove dangerous, in the highest degree, before we are aware of it. The air arising from common crude fuel is no doubt as bad, but the smoke renders it disagreeable before it becomes dangerous. The first sensation is a slight sense of weakness: the limbs seem to require a little attention, to prevent falling. A slight giddiness, accompanied by a distinct feeling of a flush, or glow in the face and neck. Soon after, the person becomes drowsy, would sit down, but commonly falls on the floor, insensible of all about him, and breathes strong, snoring as in an apoplexy. If the person is alarmed in time, and escapes into the open air, he is commonly seized with a violent headach, which gradually abates.

But when the effect is completed, as above described, death very soon ensues, unless relief be obtained. There is usually a foaming at the mouth, a great flush or suffusion over the face and neck, and every indication of an oppression of the brain, by this accumulation of blood. The most successful treatment is, to take off a quantity of blood immediately, and throw cold water on the head repeatedly. A strong stimulus, such as hartshorn, applied to the soles of the feet, has also a very good effect.

The fifth and last kind of fuel is wood, or fossil coals, in their crude state, which it is proper to distinguish from the charcoals of the same substances. The difference consists in their giving a copious and bright flame, when plenty of air is admitted to them, in consequence of which they must be considered as fuels very different from charcoal, and adapted to different purposes. See FLAME.

Flaming fuel cannot be managed like the charcoals. If little air be admitted, it gives no flame, but sooty vapour, and a diminution of heat. And if much air be admitted, to make those vapours break out into flame, the heat is too violent. These flaming fuels, however, have their particular uses, for which the others are far less proper. For it is a fact, that flame, when produced in great quantity, and made to burn violently, by mixing it with a proper quantity of fresh air, by driving it on the subject, and throwing it into whirls and eddies, which mix the air with every part of the hot vapour, gives a most intense heat. This proceeds from the vaporous nature of flame, and the perfect miscibility of it with the air.

As the immediate contact and action of air is necessary to the burning of every combustible body; so the air, when properly applied, acts with far greater advantage on flame, than on the solid and fixed inflammable bodies: for when air is applied to these last, it can only act on their surface, or the particles of them that are outermost: whereas, flame being a vapour or elastic fluid, the air, by proper contrivances, can be intimately mixed with it, and made to act on every part of it, external and internal, at the same time. This great power of flame, which is the consequence of this, does not appear when we try small quantities of it, and allow it to burn quietly, because the air is not intimately mixed with it, but acts only on the outside, and the quantity of burning matter in the surface of a small flame is too small to produce much effect.

But when flame is produced in large quantity, and is properly mixed and agitated with air, its power to heat bodies is immensely increased. It is therefore peculiarly proper for heating large quantities of matter to a violent degree, especially if the contact of solid fuel with such matter is inconvenient. Flaming fuel is used for this reason in many operations performed on large quantities of metal, or metallic minerals, in the making of glass, and in the baking or burning of all kinds of earthen ware. The potter's kiln is a cylindrical cavity, filled from the bottom to the top with columns of wares, the only interstices are those that are left between the columns; and the flame, when produced in sufficient quantity, proves a torrent of liquid fire, constantly flowing up through the whole of the interstices, and heats the whole pile in an equal manner.

Flaming fuel is also proper in many works or manufactories, in which much fuel is consumed, as in breweries, distilleries, and the like. In such works, it is evidently worth while to contrive the

furnaces so, that heat may be obtained from the volatile parts of the fuel, as well as from the fixed; for when this is done, less fuel serves the purpose than would otherwise be necessary. But this is little attended to, or ill understood, in many of those manufactories. It is not uncommon to see vast clouds of black smoke and vapour coming out of their vents. This happens in consequence of their throwing too large a quantity of crude fuel into the furnace at once. The heat is not sufficient to inflame it quickly, and the consequence is a great loss of heat. See LABORATOY.

FUGUE, in music, signifies a composition, in which one part leads off some determined succession of notes called the subject, which, after being answered in the fifth and eighth by the other parts, is interspersed through the movement, and distributed amid all the parts in a desultory manner, at the pleasure of the composer. There are three distinct descriptions of fugues: the simple, which contains but one subject; the double, that which consists of two subjects; and the counter fugue, is that in which the subjects move in a direction contrary to each other.

FUIRENA, in botany, so named in memory of George Fuiren, a genus of the Triandria Monogynia class and order. Natural order of Calamariæ. Cyperoideæ, Jussieu. Essential character: ament imbricate, with awned scales; calyx none; corolla with three-petal shaped obcordate glumes, ending in a tendril. There is but one species, *viz.* F. paniculata, a lofty grass. Native of Surinam and Jamaica.

FULCRUM, in mechanics, the prop or support, by which a lever is sustained. See MECHANICS.

FULGORA, in natural history, *lantern-fly*, a genus of insects of the order Hemiptera. Head hollow, inflated, extended forward; antennæ short, seated beneath the eyes, consisting of two joints, the outer one larger and globular; snout elongated, inflected, four-jointed; legs formed for walking. There are about 25 species, most of which inhabit hot climates. Mr. Donovan has described the F. Europæa; the body of which is green; wings hyaline, reticulate; front conic. This is a small insect, and destitute of the shining quality, by which foreign species are distinguished. But the F. lanternaria, or Peruvian lantern-fly, is one of the most curious of insects; it is three inches long, and the breadth between the tips of the expanded wings is about five or six inches. This beautiful insect is a native of Surinam and other parts of South America, and during the night it diffuses so strong a phosphoric splendour from its head, which is nearly as large as the rest of the body, that it may be employed for the purpose of a candle or torch.

Some have asserted that these insects were a source of much alarm to the Spaniards when newly arrived in South America. Observing one night a number of lights passing to and fro with much rapidity in the forest, they betook themselves precipitately to their ships, fearing an immediate attack from the natives, and were much chagrined, when they discovered the source of their alarm to be the light of this insect.

FULICA, the *gallinule* and the *coot*, in natural history, a genus of birds of the order Grallæ. Generic character: bill strong, thick, and sloping to the point; upper mandible arched over the lower at the edge, and reaching far up the forehead: nostrils nearly oval; front bald; toes four, long, and furnished with broad scalloped membranes. There are twenty-five species.

F. atra-coot, is distinguished from the gallinule by pinnated feet. It inhabits Europe, Asia, and America, and is about the size of a small fowl. It feeds on small fish and water insects, is common in some parts of this country at all seasons, but in the breeding season is seen almost always in pairs, about the borders of ponds and lakes well fringed with rushes, of which it mats itself a large nest, said to be often observed floating on the water. These birds are devoured when young by the buzzards, which infest their haunts, and prevent them from that great multiplication which might be otherwise expected. Rallus crex, or the crake gallinule, is found in various parts of Europe, and is particularly abundant in Ireland, where it is supposed by Latham to winter. Wherever quails are, the crake is to be met with. It runs fast, but flies with great awkwardness, with its legs hanging down. Its food is grain and insects. On its arrival in England, where it is migratory, it is poor and emaciated, but fattens afterwards with great rapidity, and is esteemed excellent for the table. Its full weight is about eight ounces.

F. porphyrio, or the purple water-hen, occurs in almost all the warmer latitudes of the globe. It is of the size of a fowl; in Sicily it is kept merely for its beauty,

and in Persia exhibits its greatest elegance of plumage. It is tamed with great ease, and will feed very quitely in the farm-yard on grain or roots, but is particularly fond of fishes, which it plunges in the water before it takes them to its mouth. Standing on one leg, it employs the other as a hand in many cases, particularly in lifting its food to its mouth, in the same manner as a parrot.

F. chloropus, or the common water-hen, is found in various parts of England, haunting the borders of ponds and rivers, which abound in weeds, and breeding twice in a season. It flies awkwardly, but runs and swims well. Its flesh is thought excellent, and its general weight is about fifteen ounces. Rallus Carolinus, or the American water-hen, is nearly as large as a quail. In the beginning of autumn these birds are found in the middle states in extreme abundance. From a state of perfect leanness, they speedily become so fat as to be incapable of flying to any great distance, and are knocked off the reeds of the marshes by the paddles of the Indians, who make pleasurable excursions in their canoes for this purpose, and in the course of one night a party will take ten or twelve hundred of them. They are extremely admired for food, and supply part of the daily repast of every planter during their short season. Rallus porzana, or the spotted gallinule, is found in Europe, and supposed to be migratory. It is fond of solitude, and, unless in breeding time, almost always alone. Its haunts are similar to those of the common water-hen. Its nest is built in the form of a boat, and tied or fixed to reeds to prevent its being carried off by the water. Its young run as soon as they are hatched. For the great coot, see Aves, Plate VII. fig. 4.

FULIGO, in botany, a genus of the Cryptogamia Fungi class and order. Fungus with a cellular fibrous bark; the fibres penetrating in a reticulate manner through the seminal mass.

FULLER, a workman employed in the woollen manufactories, to mill, or scour, cloths, serges, and other stuffs, in order to render them more thick, compact, and durable.

FULLER'S *earth*, in natural history, a soft, greyish, brown, dense, and heavy marle: when dry, it is of a greyish, ash-coloured brown, in all degrees from very pale to almost black, and it has generally something of a greenish cast: it is very hard and firm, of a compact texture, of a rough and somewhat dusty surface, that adheres slightly to the tongue: it is very soft to the touch, not staining the hands, nor breaking easily between the fingers: it has a little harshness between the teeth, and melts freely in the mouth: thrown into water it makes no ebullition, or hissing, but swells gradually in bulk, and falls into a fine soft powder.

It is of great use in scouring cloths, stuffs, &c. imbibing all the grease and oil used in preparing, dressing, &c. of the wool. It does not effervesce with the acids: before the blow-pipe it melts with a brown spongy scoria: it consists of

Silex - - - -	51.8
Alumine - - -	25.
Lime - - . -	3.3
Magnesia - - -	0.7
Oxide of iron - -	3.7
Water - - - -	15.5
	100.0

Fuller's earth is not now in so much request in the country as it was formerly, owing to the almost general use of soap. In England it is found in beds, covered by, and resting upon, that peculiar sandstone formation, which accompanies and serves as the foundation to chalk; its colour is yellowish grey, with a faint tinge of green. It is found in Hampshire, Bedfordshire, and in Surrey.

FULLING, the art or act of cleansing, scouring, and pressing cloths, stuffs, and stockings, to render them stronger, closer, and firmer; called also milling. The fulling of cloths and other stuffs is performed by a kind of water-mill, thence called a fulling or scouring-mill. These mills, except in what relates to the mill-stones and hopper, are much the same with corn-mills: and there are even some which serve indifferently for either use; corn being ground, and cloths fulled, by the motion of the same wheel. Whence, in some places, particularly in France, the fullers are called millers; as grinding corn and milling stuffs at the same time. The method of fulling cloths and woollen stuffs with soap is this: a coloured cloth is to be laid in the usual manner in the trough of a fulling-mill, without first soaking it in water, as is commonly practised in many places. To full this trough of cloth, 15 pounds of soap are required, one half of which is to be melted in two pails of river or spring water, made as hot as the hand can well bear it. This solution is to be poured by little and little upon the cloth, in proportion as it is laid in the trough; and thus it is to be fulled for at least two hours; after which it is to be taken out

and stretched. This done, the cloth is immediately returned into the same trough, without any new soap, and then fulled two hours more. Then taking it out, they wring it well, to express all the grease and filth. After the second fulling, the remainder of the soap is dissolved as in the former, and cast four different times on the cloth, remembering to take out the cloth every two hours to stretch it, and undo the plates and wrinkles it has acquired in the trough. When they perceive it sufficiently fulled, and brought to the quality and thickness required, they scour it in water, keeping it in the trough till it is quite clean. As to white cloths, as these full more easily and in less time than coloured ones, a third part of the soap may be spared.

FULMIANTION, in chemistry, differs from detonation only in degree; they are both the effects of rapid decomposition, accompanied by a loud noise, either with or without flame. See GOLD, MERCURY, POWDER, SILVER.

FUMARIA, in botany, English *fumitory*, a genus of the Diadelphia Hexandria class and order. Natural order of Corydales. Papaveraceæ, Jussieu. Essential character; calyx two-leaved; corolla ringent; filaments two, membranaceous, with three anthers on each. There are fifteen species.

FUMIGATION, in medicine, a process by means of which the nitrous and other mineral acids, in a state of vapour, is dispersed through the apartments of those who lie sick of infectious fevers. This method of destroying contagion, in crowded places, was first brought into practice by Dr. Carmichael Smyth, who, having given some striking proofs of its efficacy, received a reward from parliament. When this fumigation is undertaken on board ships, the ports and scuttles are closed, a number of pipkins, containing hot sand, are procured, and into each is plunged a small tea-cup, containing half an ounce of sulphuric acid. As soon as the acid is properly heated, an equal quantity of pulverised nitre is added, and the mixture stirred with a glass rod. The vapour resulting from the decomposition of nitre ascends, and is by the nurses conducted to every part of the apartment, which not only abates the malignity of the fever, but effectually stops the progress of infection. In a late volume of the "Annales de Chymie," we have some striking facts of the efficacy of fumigation, according to the method of M. Guyton de Morveau, who makes use of sulphuric acid, sea-salt, and manganese. It has been tried, and completely succeeded in stopping the progress of the rot among sheep: it has destroyed the putrid odours arising from meat in the worst possible state, as well as having been eminently successful in the cure of the most alarming fevers, and preventing the effects of contagion.

FUNARIA, in botany a genus of the Cryptogamia Musci class and order. Capsule obovate; fringe double; outer, of 16 oblique wedge-form teeth, cohering at the tips; inner, a membrane divided into 16 flat teeth; veil square. There are three species.

FUNCTION, in algebra, denotes any compound quantity; and when one of the component quantities is variable, it is said to be a variable function.

Functions are formed either by addition, subtraction, multiplication, division, involution, or evolution; as also by the resolution of equations. But besides these, which are called algebraical functions, there are others called transcendental, arising from the management of exponents, logarithms, &c.

FUNDS, *public*, the taxes or other public revenues appropriated to the payment of the interest or principal of the national debt. When the expedient of borrowing large sums for the public service was first adopted, it was found necessary to set apart and assign to the lender the produce of some branch of the revenue, supposed to be adequate to the payment of the interest or principal, or both, according to the terms of the contract; each loan had thus a separate fund provided for it, which was usually distinguished by the date of the transaction, the rate per cent. payable, or some circumstance relating to the mode of raising the money, or the purpose to which it was to be applied. These separate funds sometimes produced more than the yearly payments with which they were charged, but more frequently fell short of them; and as making good the deficiencies of some, from the surpluses of others, or from the current supplies, created much trouble and useless intricacy in the management of the public finances, it was found more convenient to combine several of the funds, and to charge the payments for which they had been set apart on the aggregate produce of the several duties. It then became necessary to give a more general denomination to the fund: and thus have been established, at different periods, the Aggregate Fund, the South Sea Fund, the General Fund, the Sinking Fund, and the Consolidated Fund.

The Aggregate Fund was established

in the year 1715, and had this name given to it, because it consisted of a great variety of taxes and surpluses of taxes, which were in that year consolidated, and given as the security for discharging the interest and principal of all the exchequer bills then outstanding, and of some other public debts: and likewise for the payment of 120,000*l.* per annum to the civil list.

The South Sea Fund was established in 1716, and was so called, because appropriated to pay the interest and allowance for management on the capital of the South Sea Company.

The General Fund was also established in 1716, by making perpetual various duties, which had been granted for the term of thirty-two years, and consolidating them with some other duties into one fund. It was appropriated chiefly to the payment of the interest on various sums raised by lotteries during the reign of Queen Anne.

The Sinking Fund consisted of the surpluses of the three funds just mentioned, whenever the produce of the taxes composing them should be greater than the charges upon them. The establishment of these funds formed part of a plan for a general reduction of the interest payable on the public debts, and this being effected, the charge on each of the three funds was of course lessened considerably, and the future overplus was directed to be carried into a fourth fund, to which was given the name of the Sinking Fund, because appropriated to the purpose of redeeming or sinking the public debts. The act of parliament by which this fund was established expressly ordained, that it should be applied to the discharge of the public debts, and "to or for none other use, intent, or purpose whatsoever;" yet in the course of a few years many encroachments were made upon it, and ultimately it became a mere nominal distinction, the whole produce of it being usually taken towards the supplies of the current year.

The Consolidated Fund was established in consequence of a new arrangement of the public accounts in the year 1786, when the funds above mentioned were abolished, and the whole of the public revenue, (except the annual grants) included under this general head. Out of this fund are paid the interest and expenses of management of all the public debts, the interest on Exchequer bills, the civil list, pensions to the royal family and others, salaries and allowances to various public officers, and some miscellaneous annual expenses. The surplus of the produce of the fund, after satisfying all these charges, is annually granted by parliament as part of the ways and means for raising the supplies voted.

Hence it appears that the public funds are properly the provision which has been made for payment of the interest or principal of the public debts, but as the possession of the acknowledgment, given by government for the money borrowed, established a right to receive the payments from the fund on which the loan was originally charged, the sale of these securities was considered as the sale of a portion of that particular fund, and as the acknowledgments given were of different kinds, the general appellation of the provision on which they rested was found more convenient for purposes of business. Thus the sale and purchase of government securities was commonly called the sale and purchase of the public funds, till, in the course of time, the expression has so far varied from its original signification, that instead of meaning the revenue out of which the interest of the public debts is payable, it denominates the capital of the debts, in which sense it is now commonly used. Thus, the possession of 1000*l.* in the public funds is understood to mean 1000*l.* capital, bearing a certain rate of interest, at 3, 4, or 5 per cent. per annum, according to the original terms of the loan.

The debts bearing a certain rate of interest, payable till the principal shall be redeemed, are denominated, in the language of finance, perpetual annuities, or redeemable annuities, but in the common course of business, they are called funds or stocks: a small part of the public debts consist of annuities for a certain term of years, commonly called long or short annuities: there are also some life and tontine annuities still existing; but the whole of the terminable annuities bears a very small proportion to the permanent debts. The perpetual annuities are distinguished according to the rate of interest they pay, or the time or purpose of their creation; and when by a new loan government contracts an additional debt, bearing a certain fixed interest, the capital thus created is added to the amount of that part of the public debt which bears the same rate of interest, and the produce of the taxes imposed for payment of the interest of such new debt being carried to the fund established for paying the interest of the former capital, the old

and new debts are consolidated, and the whole interest made payable out of the general produce of the fund; hence we have three or four per cent. consolidated annuities, according to the rate of interest payable on the capital.

The interest on all the public debts was formerly paid at the Exchequer; but the Bank being found a much more convenient place for this purpose, nearly the whole is now payable there, the company receiving a certain allowance from government for managing all business relative to the public funds. The different denominations of the funds transferable at the Bank of England, with the days on which the transfers are made, and the times when the interest or dividend becomes due, are, at present, as follows:

Funds.	Transfer days.	Dividends due:
Consolidated 3 per Cent. Annuities	Tues. Wed. Th. and Fr.	January 5, and July 5.
Three per Cent. Annuities, 1726	Tues. and Thurs.	
Navy 5 per Cent. Annuities	Mon. Wed. and Fr.	
Bank Stock	Tues. Th. and Fr.	April 5, and Oct. 10.
Five per Cent. Annuities, 1797 and 1802	Tues. Th. and Fr.	
Four per Cent. Consolidated Annuities	Tues. Th. and Sat.	
Reduced 3 per Cent. Annuities	Tues. Wed. Th. and Fr.	
Long Annuities	Mon. Wed. and Sat.	
Imperial 3 per Cent. Annuities	Mon. Wed. and Fr.	May 1, and Nov. 1.
Imperial Annuities 25 years	Tues. Th. and Sat.	
Irish 5 per Cent. Annuities	Tues. Th. and Sat.	March 25, and Sep. 25.
Irish Terminable Annuities	Tues. Th. and Sat.	

Transferable at the South Sea House.

South Sea Stock	Mon. Wed. and Fr.	January 5, and July 5.
New South Sea Annuities	Tues. Th. and Sat.	January 5, and July 5.
Three per Cent. Annuities, 1751	Tues. and Thurs.	
Old South Sea Annuities	Mon. Wed. and Fr.	April 5, and Oct. 10.

In these several funds, but particularly in the Consolidated 3 per Cents, which is by far the greatest in amount, much business is transacted daily, both at the Bank and at the Stock Exchange, a building erected expressly for the buyers and sellers of the public funds to assemble in. Persons having occasion to invest money in the funds usually employ a broker, who finds a seller of the stock wanted, and, having agreed upon the price, delivers the particulars of the transfer to be made to a clerk in the proper office at the Bank, and fills up a receipt, to be signed by the seller, for the money paid. The transaction is completed in a short time, with very little trouble to the parties, and this facility of buying into or selling out of the funds induces many persons to lay out their money therein, in preference to all other securities. The transfer from the seller to the buyer is made free of all expense to the parties, on all the government funds; but transfers of the funds of any company or society are liable to a duty. Transfers are made at the Bank between the hours of eleven and one o'clock; but may be made till three o'clock, on payment of a small fee to the clerks.

Besides the business which arises from the continual sale and purchase of property in the funds, a species of gambling has been engrafted on the fluctuations of their current price, commonly termed stock-jobbing. This consists principally in making contracts for stock, to be fulfilled some weeks or months after, without any payment or transfer being made at the time, and generally without an intention of any transfer of stock being made at all; the object of the transaction being merely to pay or receive the difference between the current price of stock at the time of making the bargain, and the price it may be at on the day fixed for settling the account. Bargains of this nature are expressly declared by an act of 7 and 8 Geo. II. to be null and void to all intents and purposes whatsoever, and persons concerned in them are in some cases liable to a heavy penalty; instances therefore frequently occur, in which persons who have entered into large speculations

in the funds, for time, refuse to fulfil their engagements, in which case those who have trusted them have no legal remedy whatever, the settlement of debts thus incurred resting, like all debts incurred by other kind of gaming, entirely on the honour of the party.

The dividends on the public funds were long expressly exempted from all taxes, charges, and impositions, whatsoever; they have, however, in common with all other descriptions of income, been lately made subject to the property tax. See Stocks.

FUNERAL *expenses*, in law, are allowed previous to all other debts and charges; but if the executor or administrator be extravagant, it is a species of devastation or waste of the substance of the deceased, and shall only be prejudicial to himself, and not to the creditors or legatees of the deceased. But, in strictness, no funeral expenses are allowable against a creditor, except for the shroud, coffin, ringing the bell, parson, clerk, grave-digger, and bearer's fees, but not for pall or ornaments.

FUNGUS, in surgery, denotes any spongy excrescence.

FUNGI, *mushrooms*. The name of one of the seven families, or tribes, into which all vegetables are divided by Linnæus in his "Philosophia Botanica." In the sexual system they constitute the fourth order of the class Cryptogamia. It is the name also of the fifty-eight order of the "Fragments." These plants are rarely branched, sometimes creep, but are most commonly erect. Such as are furnished with branches have them of a light spongy substance like cork. Mushrooms differ from the fuci, in that those, which, like the fuci, have their seeds contained in capsules, are not branched as that numerous class of sea-weed is. The greatest part of mushrooms have no root; some, in their stead, have a number of fibres, which, by their inosculations, frequently form a net with unequal meshes, some of which produce plants similar to their parent vegetable. The stamina in these plants are still undetermined. The seeds are either spread over the surface of the plant, or placed in cavities which are open, and resemble the open capsules of some of the fuci. In mushrooms which are branched, the seeds are frequently visible by the naked eye, and always to be distinctly observed with the assistance of a good microscope. See Agaric, &c.

These plants, particularly the powder of the lycoperdon, puff-ball, mixed into a paste with white of egg, are very astringent, and of familiar use for stopping violent hæmorrhages. As a vegetable food, they are, at best, suspicious. Several fungi are rank poison. Agaric is on excrescence found upon the trunks and large branches of several trees, but chiefly upon the larch, and some oaks. It is of two sorts, the male and female; the former is yellow, hard, and woody, and used for dyeing black; the latter is covered with a yellow bark, and white within: it tastes sweet at first, but becomes bitter after being held a short time in the mouth. This is the sort used in medicine.

FUR, or Furr, in commerce. See Furr.

FURIA, in natural history, a genus of the Vermes Intestina class and order, having a body linear, equal, filiform, and ciliate, each side with a single row of reflected prickles pressed close to the body: one species only is mentioned by Gmelin, *viz.* the F. infernalis, which inhabits the vast marshy plains of Bothnia and Finland, where it crawls up shrubs and sedge-grass, and being carried forwards by the wind, penetrates suddenly into the exposed parts of men and cattle, where it quickly buries itself under the skin, leaving a black point where it had entered, which is frequently succeeded by excruciating pains, inflammation, and even death. This fatal termination takes no length of time, a few hours, or a day, being sufficient for the whole process, unless the animal be almost instantly extracted by means of the knife or a milk poultice.

FURLING, in the sea language, signifies the wrapping up, and binding any sail close to the yard; which is done by hauling upon the clew-lines, buntlines, &c. which wraps the sail close together, and being bound fast to the yard, the sail is furled.

Furling *lines*, on ship board, small lines made fast to the top-sail, top-gallant-sail, and mizen-yard-arms, to furl up the sails by.

FURLONG, a long measure, equal to one-eighth of a mile, or forty poles. It is also used, in some law-books, for the eighth-part of an acre.

FURNACES. See Laboratory.

FURR, in commerce, signifies the skin of several wild beasts, dressed in alum with the hair on, and used as part of dress, by magistrates and others. The kinds mostly made use of are, those of the ermine, sable, castor, hare, rabbit, &c. It was not till the later ages that the furs

of beasts became an article of luxury. The more refined nations of ancient times never used them; those alone who were stigmatized as barbarians were clothed in the skins of animals. During Captain Cook's last voyage to the Pacific Ocean, besides various advantages derived from it, as enlarging the boundaries of science, a new source of wealth was laid open, in the exchange of European commodities for furs of the most valuable and important kind on the north west of America. Previously to this, a similar trade had been carried on, though on a much narrower scale, in Canada. It was begun by the French almost two centuries back, and in time Montreal was the grand mart of this species of commerce. The number of Indians who resorted thither increased, as the name of the Europeans was more known. Whenever the natives returned with a new supply of furs, they usually brought with them a new and more distant tribe; thus a kind of market or fair was opened, to which the several Indian nations of the new continent resorted. Our own countrymen were not long easy without sharing in this trade, and the colony at New-York soon found means to divert the stream of this great circulation. The Hudson's bay trade, carried on by a company designated as the Hudson's Bay Company, was at one time almost the only trade in this article from Great Britain; there have, however, been other persons of late years engaged in it. About twenty years ago a commercial establishment of this kind was formed, under the title of the North-West Company. It was an association of about twenty persons, agreeing among themselves to carry on the fur trade. Their capital was divided into twenty shares; of these a certain proportion was held by the people who managed the business in Canada, who were styled agents, and paid as such, independently of the profits of the trade. The articles manufactured here that are used in this traffic are, coarse woollen cloths of different kinds, blankets, arms, and ammunition, Manchester goods, all kinds of the coarser hardware, cotton, hats, and stockings.

FURRS, in heraldry, a bearing which represents the skins of certain beasts, used as well in the doubling of the mantles belonging to coat-armour, as in the coat-armours themselves. See ERMIN, ERMINOIS, &c.

FUSANUS, in botany, a genus of the Polygamia Monoecia class and order. Natural order of Elæagni, Jussieu. Essential character: hermaphrodite; calyx five-cleft; corolla none; stamens four; germ inferior; stigmas four; drupe: male, calyx, &c. of the former; fruit abortive. Only one species.

FUSEE, in clock work, is that conical part drawn by the spring, and about which the chain or string is wound; for the use of which, see CLOCK and WATCH.

FUSIL, in heraldry, a bearing of a rhomboidal figure, longer than the lozenge, and having its upper and lower angles more acute and sharp than the other two in the middle. It is called in Latin *fucus*, a spindle, from its shape.

FUSILIERS, in military affairs, are soldiers armed like the rest of the infantry, only with shorter and lighter muskets than those of the battalion and grenadiers. They wear caps, which are somewhat less in point of height than common grenadier caps. There are three regiments in the English service.

FUSION, in chemistry, the application of heat to produce the dense fluid state in bodies. See CALORIC, CHEMISTRY, GLASS, HEAT, LABORATORY.

FUSTIAN, in commerce, a kind of cotton stuff, which seems as it were whaled on one side. Right fustians should be altogether made of cotton yarn, both woof and warp; but a great many are made, of which the warp is flax, or even hemp. There are fustains made of several kinds, wide, narrow, fine, coarse; with shag or nap, and without it.

FUSTICK, in the arts, is the wood of the morus tinctoria, a tree that grows to a considerable size in the West Indies. It is much used in dyeing yellow, and produces a large quantity of colouring matter. It is not very hard, and its colour is yellow, with orange veins. From a decoction, acids throw down a slight greenish yellow precipitate, which is redissolved by alkalies. Alum throws down a scanty yellow precipitate; the sulphates of iron and copper throw down yellow and brown precipitates; acetate of lead, an orange precipitate; and muriate of tin, a very copious fine yellow precipitate.

FUTTOCKS, in a ship, the timbers raised over the keel, or the encompassing timbers that make her breadth. Of these there are, the first, second, third, and fourth, denominated according to their distance from the keel, those next it being called first or ground futtocks, and the others upper futtocks: those timbers being put together make a frame-bend.

G.

G, In grammar, the seventh letter and fifth consonant of our alphabet; but in the Greek, and all the Oriental languages, it occupies the third place. It is one of the mutes, and cannot be sounded without the assistance of some vowel. Its sound is formed by shutting the teeth gently together, so as scarce to touch, by a small incurvation of the sides of the tongue upwards, with the top touching the palate, at the same time that the breath is pretty strongly pressed through the lips a little opened.

In English it has a hard and soft sound; hard, as in the word *game, gun,* &c.; and soft, as in the word *gesture, giant,* &c.; at the end of words *gh* are pronounced like *ff*, as in the words *rough, tough,* &c The letter *g* is also used in many words where the sound is not perceived, as in *sign, reign,* &c.

As a numeral, G was anciently used to denote 400; and with a dash over it, thus, $\bar{G}$, 400,000. In music it is the character or mark of the treble cleff; and from its being placed at the head, or marking the first sound in Guido's scale, the whole scale took the name gamut.

GABEL, a word met with in old records, signifying a tax, rent, custom, or service, paid to the king, or other lord.

Gabel, according to the French duties or customs, a tax upon salt, which makes the second article in the king's revenue, and amounts to about one-fourth part of the whole revenue of the kingdom.

GABION, in fortification, is a kind of basket, made of osier-twigs, of a cylindrical form, having different dimensions, according to what purpose it is used for. Some gabions are five or six feet high, and three feet in diameter: these serve in sieges to carry on the approaches under cover, when they come pretty near the fortification. Those used in field-works are three or four feet high, and two and a half or three feet diameter. There are also gabions about one foot high, 12 inches diameter at top, and from eight to ten at bottom, which are placed along the top of the parapet, to cover the troops in firing over it; they are filled with earth.

In order to make them, some picquets, three or four feet long, are stuck into the ground, in form of a circle, and of a proper diameter, wattled together with small branches in the manner of common fences. Batteries are often made of gabions.

GAD, among miners, a small punch of iron, with a long wooden handle, used to break up the ore.

One of the miners holds this in his hand, directing the point to a proper place, while the other drives it into the vein by striking it with a sledge hammer.

Gad *fly*, or Breeze *fly*, names given to a species of Œstrus. See Œstrus.

GADUS, the *cod*, in natural history, a genus of fishes of the order Jugulares. Generic character: the head smooth; gill membrane, seven-rayed; body oblong, covered with deciduous scales; fins all covered by the common skin; more than one dorsal fin, of which the rays are unarmed; ventral fins slender and ending in a point. There are twenty-three spesies, of which we shall notice those which follow:

G. morhua, or the common cod, inhabits the northern seas, both of Europe and America, in innumerable shoals, and constitutes an important article of human subsistence. Its general length is from two or three feet, and its common weight from fourteen to thirty pounds. It has occasionally however been known to weigh upwards of seventy. Its food consists of small fish, worms, crabs, and other testaceous fishes, and its voracity is extraordinary. It is prolific in the extreme, no less than a million of eggs having been counted in a single roe. Its sound, or air-bladder, is preserved with salt, and considered as a luxury; it is also converted into a sort of isinglass, in preparing which the inhabitants of Iceland are particularly skilful. Off the coasts of Cape Breton, Nova Scotia, and New England, and, more especially, on the great sand-bank off Newfoundland, this fish is found in inexhaustible abundance; the neighbourhood of the Polar Seas, where they return to deposit their spawn, and the immense number of worms to be found in these sandy bottoms, being the grand inducements to their preference of these situations. They are abundant also on the southern and western coasts of Iceland, but proceed towards the south only in very diminished numbers, and are rarely seen in that direction beyond the Straights

of Gibraltar. Before the discovery of Newfoundland, in 1496, Iceland was the principal scene for the cod fishery, which was speedily after that event transferred to Newfoundland, where it is conducted to such an extent, merely by the hook, baited with the herring and other small fishes, as to furnish employment for fifteen thousand British seamen, and to a more numerous portion of population at home, occupied on the various articles of manufacture, indispensible for a concern of such vast extent and importance.

C. aeglefinus, or the haddock, is distinguished from every other species by its forked tail, and by having the lower jaw longer than the upper. These fishes abound in the northern seas, and are found at particular seasons on particular coasts, to which they approach in shoals of several miles in length. On the coasts of Yorkshire they are particularly abundant in the season, which has been known to commence on the same day of the month in two successive years.

Three men will not unfrequently, during the continuance of these fishes on the coast, take three tons of them in a day: and they have been often sold to the poor for the low price of a half-penny a score. In stormy weather the haddock shelters itself in the mud at the bottom. Its general length is eighteen inches, and weight two pounds and a half.

G. merlangus, or the whiting, is, generally, about twelve inches long, and is elegantly formed. It abounds in the northern seas, and is found in some parts of the Mediterranean. In the spring, whitings are caught on the British coasts in immense abundance, and they are considered by many as preferable for the table to every other species of the cod genus. Their favourite food consists of sprats and herrings.

G. pollachius, or the pollack, is found in the Baltic and Northern Seas, and on the coast of England also, in vast shoals, during the summer, at which time these fishes are so prone to catch at any thing on the surface of the water, that they may be caught only with a hook and feather. In the most boisterous and tempestuous weather they are strong enough to keep their situation, and resist the impetuosity of the waves. Their general weight is from two to four pounds.

G. merluccius, or the hake, is usually from one to two feet in length. It is found in the Mediterraneam and Northern seas, and abounds on the English coast, and still more on that of Ireland; and to the poor of these countries is a considerable article of food. Being, however, a coarse fish, it is rarely seen at the tables of the opulent. They feed principally on the mackrel and herring. On the coasts of Brittany an extensive hake fishery is carried on, and almost always by night. On the coast of Waterford six men would, in the course of a single night, take a thousand of these fishes with a rod and line.

G. molva, or the ling (a word implying length) is generally from three to four feet in length, and has, occasionally, been seen of seven. These fishes are found in the depths of the Northern Seas, and constitute a considerable article of merchandize in Great Britain itself. Great numbers are salted and preserved for home consumption, as well as for exportation, for the last of which it is required by statute, that in order to any persons being entitled to the bounty on sending them abroad, they should measure twenty-two inches exclusively of the head. During their continuance in season, their liver is white and oily, but as they decline, these qualities proportionably diminish, and at length totally disappear.

G. lota, or the burbot, is to be met with in various parts, both of Europe and Asia, frequenting clear streams and lakes. In the Trent and Witham rivers, and in the fens of Lincolnshire, it is also highly abundant. Its food consists of almost all the smaller fishes, and also of worms and frogs. Its general weight is between two and three pounds, and it is regarded as excellent for the table. Its liver is particularly celebrated, as furnishing the most luxurious banquet.

GADOLINITE, in mineralogy, a metallic fossil, first discovered by Dr. Gadolin, from whom it is named; it is also called yttria from Ytterby, where it is found; its colour is black, passing into brownish black; it occurs massive, is shining, and its lustre is vitreous; fracture conchoidal; it is hard, scratches quartz slightly, is opaque, brittle, and of a specific gravity 4.05; it attracts the magnetic needle. When pulverized and heated with dilute nitric acid, it is converted into a yellowish-grey thick jelly. It decrepitates before the blow-pipe, assumes a redish white colour, and remains unfused if the fragments are not very minute; with borax it is converted into a yellow-coloured glass. A new earth, to which the name of yttria has been given, has been discovered in it; according to Vauquelin it consists of

Yttria	35.
Silica	25.5
Iron	25.0
Oxide of manganese	2.0
Lime	2.0
Water and carbon .	10.5
	100.0

It has been found no where but at Ytterby, in Sweden.

GÆRTNERA, in botany, in memory of Joseph Gærtner, M. D. F. R. S. a genus of the Decandria Monogynia class and order. Essential character: calyx five-parted, the leaflets having on the outside a single marginal gland; corolla five-petalled, somewhat unequal, tooth-letted, furnished with very short claws; seed vessel nearly globose, with four wings. There is but one species, *viz.* G. racemosa, a native of the East Indies, in the Circar mountains.

GAFF, in naval affairs, a sort of boom used in small ships, to extend the upper edge of the mizen, and employed for the same purpose on those sails, whose foremost edges are joined to the masts by hoops or lacings, and which are usually extended by a boom below; such are the main-sails of sloops, brigs, and schooners. Gaff top-sail, is a light quadrilateral sail, the head being extended on a small gaff, which hoists on the top-mast, and the foot spreading from the throat to the extent of the lower gaff.

GAGE, in the sea language. When one ship is to windward of another, she is said to have the weather-gage of her. They likewise call the number of feet that a vessel sinks in the water, the ship's gage: this they find by driving a nail into a pike near the end, and putting it down beside the rudder till the nail catch hold under it; then as many feet as the pike is under water is the ship's gage.

Gage, among letter-founders, a piece of box or other hard wood, variously notched; the use of which is to adjust the dimensions, slopes, &c. of the different sorts of letters.

Gage, *sliding*, a tool used by mathematical instrument makers, for measuring and setting off distances. It is also of use in letter-cutting, and making of moulds.

GAHNIA, in botany, so named in honour of Henry Gahn, a genus of the Hexandria Monogynia class and order. Essential character: glume two valved, irregular; nectary two-valved, involving the filaments; stigma dichotomous. There are two species.

GAINAGE, in old law books, properly signifies the plough-tackle, or implements of husbandry; but is also used for the grain or crop of ploughed lands.

GALANTHUS, in botany, *snow-drop*, a genus of the Hexandria Monogynia class and order. Natural order of Spathaceæ, Narcissi, Jussieu. Essential character: petals three, concave; nectary of three small emarginate petals; stigma simple. There is but one species, *viz.* G. nivalis, snow-drop.

GALARDIA, in botany, a genus of the Syngenesia Polygamia Frustranea class and order. Natural order of Corymbiferæ. Essential character: receptacle chaffy; seed crowned with the five-leaved calycle; calyx of two rows of scales almost equal. There is only one species, *viz.* G. alterni-folia.

GALAX, in botany, a genus of the Pentandria Monogynia class and order. Essential character: calyx ten-leaved; corolla salver-shaped; capsule one-celled, two-valved, elastic. There is but one species, *viz.* G. aphylla.

GALAXIA, in botany, a genus of the Monadelphia Triandria class and order. Natural order of Ensatæ. Irides, Jussieu. Essential character: spathe one-valved; corolla one-petalled, six-cleft; tube capillary; stigma many-parted. There are two species, both natives of the Cape of Good Hope.

GALAXY, in astronomy. A very remarkable appearance in the heavens is that called the galaxy, or the milky-way. This is a broad circle, sometimes double, but for the most part single, surrounding the whole celestial concave. We perceive also in different parts of the heavens small white spots, which appear to be of the same nature with the milky-way. These spots are called nebulæ.

With a powerful telescope, Dr. Herschel first began to survey the via lactea, and found that it completely resolved the whitish appearance into stars, which the telescope he formerly used had not power enough to do. The portion he first observed was that about the hand and club of Orion; and found therein an astonishing multitude of stars, whose number he endeavoured to estimate, by counting many fields, and computing from a mean of these how many might be contained in a given portion of the milky-way. In the most vacant place to be met with in

that neighbourhood, he found 63 stars; other six fields contained 110, 60, 70, 90, 70, and 74 stars; a mean of all which gave 79 for the number of stars to each field; and thus he found, that by allowing 15 minutes for the diameter of his field of view, a belt of 15 degress long and two broad, which he had often seen pass before his telescope in an hour's time, could not contain less than 50,000 stars, large enough to be distinctly numbered; besides which, he suspected twice as many more, which could be seen only now and then by faint glimpses, for want of sufficient light. The success he had within the milky-way soon induced him to turn his telescope to the nebulous parts of the heavens, of with an accurate list had been published in the "Connoisance des Temps, for 1783 and 1784." Most of these yielded to a Newtonian reflector, of 20 feet focal distance, and 12 inches aperture; which plainly discovered them to be composed of stars, or at least to contain stars, and to show every other indication of its consisting of them entirely.

"The nebulæ (says he) are arranged in strata, and run on to a great length, and some of them I have been able to pursue, and to guess pretty well at their form and direction. It is probable enough that they may surround the whole starry sphere of the heavens, not unlike the milky-way, which undoubtedly is nothing but a stratum of fixed stars: and as this latter immense starry bed is not of equal breadth or lustre in every part, nor runs on in one straight direction, but is curved, and even divided into two streams along a very considerable portion of it, we may likewise expect the greatest variety in the strata of the cluster of stars and nebulæ. One of these nebulous beds is so rich, that in passing through a section of it in the time of only 36 minutes, I have detected no less than 31 nebulæ, all distinctly visible upon a fine blue sky. Their situation and shape, as well as condition, seem to denote the greatest variety imaginable. In another stratum, or perhaps a different branch of the former, I have often seen double and treble nebulæ variously arranged; large ones, with small seeming attendants; narrow, but much extended lucid nebulæ or bright dashes; some of the shape of a fan, resembling an electric brush issuing from a lucid point; others of the cometic shape, with a seeming nucleus in the centre, or like cloudy stars, surrounded with a nebulous atmosphere: a different sort, again, contain a nebulosity of the milky kind, like that wonderful inexplicable phenomenon about Orion is; while others shine with a fainter mottled kind of light, which denotes their being resolvable into stars.

"It is very probable that the great stratum, called the milky-way, is that in which the sun is placed, though perhaps not in the very centre of its thickness. We gather this from the appearance of the galaxy, which seems to encompass the whole heavens, as it certainly must do, if the sun is within the same; for, suppose a number of stars arranged between two parallel planes, indefinitely extended every way, but at a given considerable distance from one another, and calling this a sideral stratum, an eye placed somewhere within it will see all the stars in the direction of the planes of the stratum projected into a great circle, which will appear lucid, on account of the accumulation of the stars, while the rest of the heavens, at the sides, will only seem to be scattered over with constellations, more or less crowded, according to the distance of the planes, or number of stars, contained in the thickness or sides of the stratum."

GALBANUM, in pharmacy, is obtained from the bubon galbanum, a plant found in Africa. By cutting the plant across, a milky juice flows out, which soon hardens, and constitutes galbanum. It is brought here from the Levant, in small pieces, agglutinated together; its taste is acrid, and its smell strong; the specific gravity is 1.2. It is partly soluble in water and alcohol, and when distilled, it yields about half its weight of volatile oil, which is of a bluish colour.

GALBULA, the *jacamar*, in natural history, a genus of birds of the order Picæ. Generic character: bill strait, very long, quadrangular, and pointed; nostrils situated near the base of the bill, and oval; tongue pointed and short; legs feathered before, down to the toes; feet formed for climbing. There are four species.

G. alcedo, is about the size of a lark, and is of a most elegant and brilliant plumage. It is found in the damp places of the woods of Guiana and Brazil, feeding on insects, and is of very solitary and sequestered habits, continuing motionless on its perch during the whole night, and often also a considerable part of the day, and but rarely seen otherwise than alone. Naturalists are but imperfectly acquainted with the jacamar genus, and know nothing of its nest and eggs.

GALEGA, in botany, a genus of the Diadelphia Decandria class and order. Natural order of Papilionaceæ, or Leguminosæ. Essential character: calyx with subulate teeth, nearly equal; legume with oblique streaks between the seeds. There are nineteen species.

GALENIA, in botany, a genus of the Octandria Digynia class and order. Natural order of Succulentæ. Attriplices, Jussieu. Essential character: calyx four-cleft; corolla none; capsule roundish, two-seeded. There are two species.

GALEOPSIS, in botany, a genus of the Didynamia Gymnospermia class and order. Natural order of Verticillatæ, or Labiatæ. Essential character: corolla upper-lip notched a little, vaulted; lower has two teeth above. There are four species, with several varieties.

GALILEI, or GALILEO, in biography, a most excellent philosopher, mathematician and astronomer, was the son of a Florentine nobleman, and born at Pisa, in the year 1564. The earliest subjects of his studies were, poetry, music, and drawing; but his genius soon led him to the cultivation of sublimer sciences, by his proficiency in which he has immortalized his name. His father, though a noble, possessed but a limited fortune, and was therefore desirous of educating him a physician, that he might secure greater means of independence from the profits of his profession, than he could derive from his paternal estate. With this view he entered him as a student in philosophy and medicine at the university of Pisa; but Galileo became soon dissatisfied with the obscurity of the Aristotelian system then taught in the schools, and conceived an unconquerable dislike to medical studies.

He now betook himself to the study of the mathematics, and, without the assistance of a tutor, made a rapid progress in those sciences, commencing with Euclid, and afterwards making himself master of the works of Archimedes, and of other ancient mathematicians. When his father perceived which way his inclination tended, and that his improvement indicated uncommon talents for mathematical pursuits, he prudently suffered him to follow the natural bias of his mind without any restraint. So great was the reputation he acquired as a mathematician, that, in the year 1589, the Duke of Tuscany appointed him to the mathematical chair in the University of Pisa. He discharged the duties of this appointment, for about three years, with the applause and admiration of the liberal and more enlightened; but not without exciting the jealousy and opposition of the violent Aristotelians, who, because he ventured to question some of the hypothetical maxims of their master, held him out in the odious light of a visionary and dangerous innovator. Becoming disgusted with the obstructions which their ignorance and bigotry threw in the way of his promoting just principles of science, in the year 1592 he resigned his professorship at Pisa, and accepted with pleasure of an invitation that was sent him to fill the mathematical chair in the university of Padua. In this seminary he continued for eighteen years, esteemed and cherished by the Paduans and Venetians, raising the credit of the university as a school of sound philosophy, and admired by all the learned, who had sufficient liberality and spirit to emancipate themselves from the fetters of ancient prejudices.

By degrees Tuscany felt an increasing ardour for improvement, and no sooner was it known that Galileo's patriotism inclined him to devote his services to his native country, than Cosmo II. Grand Duke, sent for him to Pisa in the year 1611, where he made him professor of mathematics, with a very considerable stipend. Afterwards he invited him to Florence, and gave him the title of principal mathematician and philosopher to his highness, continuing to him the salary annexed to his professorship, without any obligation to a residence at Pisa. With the study of mathematics, Galileo united that of physics, particularly the doctrines of mechanics and optics. Before he had settled at Padua, he had written his "Mechanics," or treatise on the benefits derived from that science, and its instruments; and also his "Balance," for finding the proportion of alloy or mixed metals. These he had introduced into his lectures at that university.

Being informed at Venice, in the year 1609, that Jansen, a Dutchman, had invented a glass, by means of which distant objects appeared as if they were near, he turned his attention to this subject, and from the imperfect accounts he had received, and his own reflections on the nature of refraction, discovered the construction of that instrument. The next day after he had solved the problem of its construction, he made such an instrument, and, by the attention which he paid to its perfection and improvement, may justly be considered as the

second inventor of the telescope. He now turned his instrument towards the heavens, and discovered unheard of wonders. He perceived the surface of the moon not to be smooth, but rough, and full of prominences and cavities. The milky way he found to be an assemblage of fixed stars, invisible to the naked eye. Venus he found to vary in its phases like the moon. The figure of Saturn he observed to be oblong, and imagined that it consisted of three distinct parts, one spherical in the midst, and two lesser ones on the sides, which afterwards appeared to be only the ansæ, or extreme parts of Saturn's ring. Jupiter he saw surrounded with four moons, which, in honour of the Duke de Medici, he called Medicean stars, and soon perceived that, by means of their frequent eclipses, geographical longitudes might be found. On the sun's disk he perceived spots, from the motion of which he inferred that the sun revolved on its axis.

It was while he was pursuing these discoveries, that he was invited to Florence, where, as we have seen, he had leisure afforded him to devote himself to his mathematical and philosophical studies, without being obliged to attend to the duties of his professorship. In a very few years, however, his tranquillity was disturbed by the ignorant and bigotted clergy, on account of the zeal which he discovered for illustrating and confirming the truth of the Copernican system. That system they maintained to be false and heretical, as being contrary to the plain and express language of the scriptures; and by their complaints against him to the Inquisition at Rome, rendered it necessary for him, in the year 1615, to appear in that city to justify himself. According to letters written from Rome, by the learned Anthony Quezenghi, Galileo did not lose his courage on this occasion, but, in numerous companies of men of letters and others, defended the Copernican doctrine with a force of argument, which persuaded many of its truth and reasonableness, and silenced the objections of others, who would not be convinced. When he attended the Inquisition, however, he was not suffered to enter into any explanations, but was directly accused of heresy for maintaining the two propositions, that the sun is the centre of the world, and immoveable by a local motion, and that the earth is not the centre of the world, nor immoveable, but moves with a diurnal motion. These propositions he was ordered by a decree of the Inquisitors to renounce, and not to defend them either in conversation or writing, or even to insinuate them into the minds of any persons whomsoever. Most accounts concur in stating, that, on this occasion, he was committed to the prison of the Holy Office, where he was confined for about five months; but, according to other accounts, he was treated with greater mildness, and only threatened with imprisonment if he proved refractory. Be that as it may, he was not permitted to quit Rome until he had promised to conform himself to the decree of the Inquisition; and it is probable that his sentence would have been more severe, had not the Grand Duke of Tuscany warmly interested himself on his behalf, as well as some persons of high rank and influence at the papal court.

Galileo now returned to his studies, in which his astronomical observations, and other happy discoveries, served to establish most completely and satisfactorily the truth of his obnoxious opinions. From time to time he laid before the public an account of his discoveries, with such remarks and inferences as tended to point out the natural conclusions to be drawn from them. At length, in the year 1632, he ventured to publish, at Florence, his famous "Dialogues on the two greatest systems of the World, the Ptolemaic and Copernican;" in which he produced the strongest arguments in favour of both systems, without expressing a decided opinion which of them was the true one, but not without such insinuations in favour of the Copernican, as sufficiently indicated its superior reasonableness, and his own belief in it. These dialogues, likewise, contain some keen strokes of raillery against the Aristotelians, for their bigotted and servile attachment to every hypothesis of their master.

Scarcely had this work made its appearance, before the cry of heresy was raised more loudly than ever against Galileo, and he was again cited to appear before the tribunal of the Inquisition, in the year 1633. Though now seventy years of age, he was obliged to submit to the persecuting mandate, and on his arrival at Rome was first committed prisoner to the apartments of the Fiscal of the Holy Office. Afterwards, through the intercession of the Grand Duke, he was permitted to reside in the house of his embassador, while the process was carrying on against him. After his trial had lasted about two months, he

was brought up to receive sentence in full congregation; when he was ordered, in the most solemn manner, to abjure and condemn the Copernican system, as contrary to the Scriptures, and to bind himself, by oath, no longer to teach or support it, either directly or indirectly. As a punishment for having disobeyed the former decree of the court, he was condemned to be detained in the prisons of the Holy office, during the pleasure of the Cardinal Inquisitors, and enjoined, as a saving penance, for three years to come, to repeat, once a week, the seven penitential psalms, the court reserving to themselves the power of moderating, changing, and taking away altogether, or in part, the above-mentioned punishment and penance His dialogues were also censured, prohibited, and ordered to be burnt at Rome.

Pope Urban VIII. who at that time sat on the Pontifical throne, lessened the rigour of his sentence, by confining him for a time to the palace and garden de Medici at Rome; after which he was sent to the archi-episcopal palace at Sienna, where the air was more favourable to his state of health; and in the course of the year 1634, he was permitted to reside at his country house at Ancetri, in the vicinity of Florence.

In this place he spent the remainder of his days, visited and esteemed by the most distinguished characters in Florence, and diligently applying himself to his celestial observations. By his continual use of the telcscope, however, and the injuries which his eyes received from the nocturnal air, his sight was gradually impaired, till he became entirely blind about three years before his death. This calamity he bore with a truly philosophical resignation, employing himself in constant meditation and enquiry, the result of which he intended to communicate to the world. He had digested much matter, and had begun to dictate his conceptions, when he was attacked by a distemper which terminated in his death, in 1642, when he was in the seventy-eighth year of his age.

Galileo was small in stature, but of a venerable aspect, and of a vigorous constitution. His learning was very extensive; and he possessed, in a high degree, a clearness and acuteness of wit. In company he was free and affable, and full of pleasantry.

He took great delight in Architecture and Painting, and designed extremely well; and he also played on the lute with great skill and taste. Whenever he spent any of his time in the country, he took great pleasure in husbandry. From the time of Archimedes, as M. Leibnitz observes, there had been nothing done in mechanical geometry, till Galileo, who, possessing an excellent judgment, and great skill in the most abstruse points of geometry, first extended the boundaries of that science, and began to reduce the resistance of solid bodies to its laws. We shall follow the example of Dr. Hutton, in giving a summary sketch of his discoveries and improvements, chiefly in the language of the judicious Colin Maclaurin. "He made the evidence of the Copernican system more sensible, when he showed from the phases of Venus, like to the monthly phases of the moon, that Venus actually revolves about the sun. He proved the revolution of the sun on his axis, from his spots; and thence the diurnal rotation of the earth became more credible. The four satellites that attended Jupiter, in his revolution about the sun, represented, in Jupiter's lesser system, a just image of the great solar system, and rendered it more easy to conceive how the moon might attend the earth, as a satellite, in her annual revolution. By discovering hills and cavities in the moon, and spots in the sun constantly varying, he showed that there was not so great a difference between celestial and sublunary bodies as the philosophers had vainly imagined.

"He rendered no less service to science, by treating, in a clear and geometrical manner, the doctrine of motion, which has been justly called the key of nature. The rational part of mechanics had been so much neglected, that scarcely any improvement was made in it for almost 2000 years; but Galileo has given as fully the theory of equable motions, and of such as are uniformly accelerated or retarded, and of these two compounded together. He first demonstrated, that the spaces described by heavy bodies, from the beginning of their descent, are as the squares of the times; and that a body, projected in any direction that is not perpendicular to the horizon, describes a parabola. These were the beginnings of the doctrine of the motion of heavy bodies, which has been since carried to so great a height by Sir Isaac Newton. In geometry, he invented the cycloid, or trochoid, though the properties of it were afterwards chiefly demonstrated by his pupil Torricelli. He in-

vented the simple pendulum, and made use of it in his astronomical experiments: he had also thoughts of applying it to clocks, but did not execute that design. The glory of that invention was reserved for his son Vincenzo, who made the experiment at Venice in 1649; and Huygens afterwards carried the invention to perfection. Of Galileo's invention also was the machine with which the Venetians render their laguna fluid and navigable.

"He also discovered the gravity of the air, and endeavoured to compare it with that of water; and opened several other inquiries in natural philosophy. He was not esteemed and followed by philosophers only; but was honoured by persons of the greatest distinction of all nations. Galileo had scholars worthy of so great a master, by whom the gravitation of the atmosphere was fully established, and its varying pressure accurately and conveniently measured, by the column of quicksilver of equal weight sustained by it in the barometrical tube. The elasticity of the air, by which it perpetually endeavours to expand itself, and while it admits of condensation, resists in proportion to its density, was a phenomenon of a new kind, (the common fluids having no such property,) and of the utmost importance to philosophy. These principles opened a vast field of new and useful knowledge, and explained a great variety of phenomena, which had been accounted for in an absurd manner before that time. It seemed as if the air, the fluid in which men lived from the beginning, had been then first discovered. Philosophers were every where busy, enquiring into the various properties and their effects; and valuable discoveries rewarded their industry. Of the great number who distinguished themselvs on this occasion, we cannot but mention Torricelli and Viviani, in Italy; Pascal, in France; Otto Guricke, in Germany; and Boyle. in England."

Galileo wrote a number of treatises, of which the principal, published during his life-time, besides his "Mechanics," "Balance," and "Dialogues," already mentioned, were, "The Operations of the Compass, geometrical and military," 1606; "A Discourse, addressed to the Most Serene Cosmo II. Grand Duke of Tuscany, concerning the swimming of Bodies upon, and their submersion in, Water," 1612: "Nuncius Sidereus," 1610, of which a "Continuation," or "An Essay on the History of Galileo's last Observations on Saturn, Mars, Venus, and the Sun, &c."was afterwards collected from letters between Galileo and his correspondents; "A Letter concerning the Trepidation of the Moon, lately discovered, inscribed to Alphonso Antonini, with Antonini's Answer," 1638, "A Discourse of the Solar Spots, &c. with Predictions and Ephemerides of the Medicean Planets," 1613; the famous Italian piece, entitled, "Il Saggiatore," written in defence of Guiducci's "Discourse on Comets," and containing a complete account of the physiology and astronomy of our author, printed in 1623; "A Letter to Prince Leopold of Tuscany, examining the fiftieth chapter of Licetus's Letheosphoros;" "A Letter to Christopher Greinbergerus, concerning the Montuosity of the Moon," 1611; "Mathematical Discourses and Demonstrations concerning two new Sciences, relating to Mechanics and local Motions, together with an Appendix concerning the Centre of Gravity in some Solids," 1638, &c.

The preceding articles, together with some other treatises, written either by Galileo, or by some of his disciples, in defence of his doctrines and observations, were collected and published by Menolessi, in 1656, under the title of "l'Opere de Galileo Galilei Lynceo, nobile Florentino," &c. in two volumes quarto. Several of these pieces were translated into English, and published by Thomas Salisbury, in his "Mathematical Collections," in two vols. folio.

A volume also of his "Letters," to several learned men, and solutions of a variety of problems, was published at Bologna, in quarto. His last disciple, Vincenzo Viviani, who proved a very eminent mathematician, methodised a piece of his master's, and published it under the title of "Quinto Libro de gli Elementi d'Euclid," &c. 1674, quarto; and he also published some other pieces of Galileo, including extracts from his "Letters to a learned Frenchman," in which the author gives an account of the works which he intended to have published, and an extract of a letter to John Camillo, a mathematician of Naples, concerning the angle of contact. Many other of Galileo's writings were unfortunately lost to the world, owing to the superstition of one of his ignorant nephews; who, considering that his uncle died a prisoner of the holy office, though permitted to reside in his own house, suspected that his papers might contain dangerous heresies, and therefore committed them to the flames.

Sir John Finch, in a letter to Thomas Salisbury, attributes the destruction of Galileo's MSS. to his widow's devotion, and the fanaticism of her confessor: but the best authorities maintain that our philosopher was never married. His son Vincenzo Galilei, who, as we have already seen, honourably supported his father's reputation, by first applying his invention of the pendulum to clock-work, was of illegitimate birth.

GALIUM, in botany, a genus of the Tetrandria Monogynia class and order. Natural order of Stellatæ. Rubiaceæ, Jussieu. Essential character: corolla one-petalled, flat; seeds two, roundish. There are forty-eight species.

GALL, in the animal economy, the same with bile. See Bile.

Gall, in natural history, denotes any protuberance or tumour, produced by the puncture of insects on plants and trees of different kinds. Galls are of various forms and sizes, and no less different with regard to their internal structure. Some have only one cavity, and others a number of small cells communicating with each other, or entirely separate; some of them are as hard as the wood of the tree they grow on, whilst others are soft and spongy; the first being termed gall-nuts, and the latter berry-galls, or apple-galls.

The general history of galls is this: an insect of the fly-kind (see Cynips), is instructed by nature to take care for the safety of her young, by lodging her eggs in a woody substance, where they will be defended from all injuries, and be able to procure a sufficiency of nutriment, proper for them, consisting of the juices of the plant upon which they are placed: she for this purpose wounds the branches or leaves of a tree, and the lacerated vessels, discharging their contents, soon form tumours about the holes thus made. These tumours are gradually increased to their full size by the morbid action of the vessels of the plant, occasioned by the continual and peculiar stimulus of the included infant cynips: and, although their variety is very great, of form, size, colour, and consistence, it is no difficult matter for the practised eye to determine the species of cynips by the appearance of its gall. The hole in each of these tumours, through which the fly, when arrived at perfection, has made its way, may for the most part be found; and when it is not, the maggot-inhabitant, or its remains, are sure to be found within, on breaking the gall. It is to be observed, however, that in those galls which contain several cells, there may be insects found in some of them, though there is a hole by which the inhabitant of another cell has escaped. Oak-galls, put in a very small quantity into a solution of vitriol in water, though but a very weak one, gives it a purple or vitriol colour, which as it grows stronger becomes black; and on this property depends the art of making our writing-ink, as also a great deal of those of dyeing and dressing leather, and other manufactures. See Ink, &c.

Gall *bladder*, called vesicula, is usually of the shape of a pear, and of the size of a small hen's egg. It is situated in the concave side of the liver, and lies upon the colon, part of which it tinges with its own colour. The use of the gall-bladder is to collect the bile, first secreted in the liver, and mixing it with its own peculiar produce, to perfect it farther, to retain it together a certain time, and then to expel it.

Gall *fly*. See Cynips.

Gall *stone*. See Calculi *biliary*.

GALLEON, in naval affairs, a sort of ships employed in the commerce of the West Indies. The Spaniards send annually two fleets; the one for Mexico, which they call the flota, and the other for Peru, which they call the galleons.

By a general regulation made in Spain, it has been established that there should be twelve men of war, and five tenders, annually fitted out for the armada or galleons; eight ships of six hundred tons burden each, and three tenders, one of an hundred tons, for the island Margaritta, and two of eighty each, to follow the armada; for the New Spain fleet, two ships of six hundred tons each, and two tenders of eighty each; and for the Honduras fleet, two ships of five hundred tons each; and, in case no fleet happened to sail any year, three galleons and a tender should be sent to New Spain for the plate. They were formerly appointed to sail from Cadiz, in January, that they might arrive at Porto-Bello about the middle of April, where the fair being over, they might take aboard the plate, and be at Havanna with it about the middle of June, where they were joined by the flota, that they might return to Spain with the greater safety. For this purpose the viceroy of Peru was to take care that the plate should be at Panama by the middle of March. The plate is fifteen days removing from Potosi to Arica, eight days generally from thence by sea to Callao, and

from that place to Panama twenty days, taking in by the way the plate at Paita and Truxillo. It has, however, been found by experience, that the month of September is the fittest for the fleet to sail: they are about two years in the whole voyage.

The galleons bring annually of gold about two or three millions of crowns, and the flota one. Of silver, the galleons bring eighteen or twenty thousand crowns and the flota ten or twelve. Of precious stones, the galleons bring quantities to an immense value; besides fine wool, leather, and Campeachy wood.

GALLERY, in fortification, a covered walk across the ditch of a town, made of strong beams, covered over head with planks, and loaded with earth; sometimes it is covered with raw hides, to defend it from the artificial fires of the besieged. Its sides should be musket proof.

GALLERY *of a mine*, is a narrow passage, or branch of a mine carried on under-ground to a work designed to be blown up. Both the besiegers and the besieged also, carry on galleries in search of each other's mines, and these sometimes meet and destroy each other.

GALLERY, in ship-building, a balcony, projecting from the stern or quarter of a ship of war, or of a large merchantman: the stern-gallery is wholly at the stern of the ship, and is usually decorated with a balustrade, extending from one side of the ship to the other; the fore part is limited by a partition, in which are framed the cabin windows, and the roof of it is formed by a sort of vault termed the cove, which is frequently ornamented with sculpture. Quarter-gallery is that part which projects on each quarter, and is generally fitted up as a water closet. Ships of twenty guns and upwards, on one deck, have quarter galleries, but no stern gallery; two and three deckers have quarter galleries, with their proper conveniencies, and one or two stern galleries.

GALLEY, in naval affairs, a low-built vessel, using both sails and oars, and commonly carrying only a main-mast and fore-mast, which may be struck or lowered at pleasure. Such vessels are much used in the Mediterranean.

These vessels are of a long standing, though it is probable the construction of those in modern times is very different from that formerly adopted. Galleys are of a finer and slenderer make than ships. Galley is the name also of an open boat, rowing six or eight oars, and used on the Thames by custom-house officers, press-gangs, and also for pleasure. The same word denotes the kitchen of a ship of war, or the place where the grates are put up, fires lighted, and the victuals generally dressed.

GALLEY *slave*, a person condemned, in France, to work at the oar on board a galley, being chained to the deck.

GALLIC-*acid*, in chemistry, exists in nut-galls, and is obtained by boiling together for some time carbonate of barytes, and a solution of gall-nuts. This affords a bluish green liquid, which consists of a solution of gallic acid and barytes. It is now to be filtered and saturated with diluted sulphuric acid. Sulphate of barytes is deposited in the state of insoluble powder, and a colourless solution of gallic acid remains behind. This is the method given by Mr. Davy; others have been suggested by almost every practical chemist. Gallic-acid, pure, is in the form of transparent plates or octahedrons. Its taste is acid, and somewhat astringent, and when heated has rather an unpleasant aromatic odour. It is soluble in about twelve parts of cold water, and in three parts of alcohol: it is soluble in ether. It combines with alkaline bodies, making with them compounds called gallates. It occasions a precipitate when poured into solutions of glucina, yttria, and zircon, in acids, which distinguishes these from the other earths, none of which are precipitated from their solutions by gallic-acid. Upon the metallic solutions gallic-acid acts with great energy, changing the colour, and producing precipitates in many of them. Hence it is frequently used as a re-agent, to detect the presence of metallic bodies. It is composed of oxygen, carbon, and hydrogen, but the proportions of each have not been accurately ascertained.

GALLIOT, a small galley, designed only for chase, carrying only one mast, and two or three pattereroes; it can both sail and row, and has sixteen or twenty oars. All the seamen on board are soldiers, and each has a musket by him on quitting his oar.

GALLON, a measure of capacity both for dry and liquid things, containing four quarts; but these quarts, and consequently the gallon itself, are different, according to the quality of the thing measured:

for instance, the wine gallon contains 231 cubic inches, and holds eight pounds averdupois of pure water: the beer and ale gallons contain 282 solid inches, and hold ten pounds three ounces and a quarter averdupois, of water: and the gallon for corn, meal, &c. 272¼ cubic inches, and holds nine pounds thirteen ounces of pure water.

GALLOON, in commerce, a narrow thick kind of ferret, or lace, used to edge or border clothes, sometimes made of wool, and at other times of gold or silver.

GALLY, in printing, a frame into which the compositor empties the lines out of his composing stick, and in which he ties up the page when it is completed. The gally is formed of an oblong square board, with a ledge on three sides, and a groove to admit a false bottom, called a gally-slice.

GALOPINA, in botany, a genus of the Tetrandria Digynia class and order. Natural order of Rubiaceæ, Jussieu. Essential character: calyx none; corolla four-cleft; seeds two, naked. There is one species, *viz.* G. circæoides, a native of the Cape of Good Hope.

GALVANI (Lewis) a modern physiologist, who has had the honour of giving his name to a supposed new principle in nature, was born in 1737, at Bologna, where several of his relations had distinguished themselves in jurisprudence and theology. From his early youth he was much disposed to the greatest austerities of the Catholic religion, and particularly frequented a convent, the monks of which attached themselves to the solemn duty of visiting the dying. He shewed an inclination to enter into this order, but was diverted from it by one of the fraternity. Thenceforth he devoted himself to the study of medicine in its different branches. His masters were, the Doctors Beccari, Jacconi, Galli, and especially the Professor Galleazzi, who received him into his house, and gave him his daughter in marriage. In 1762, he sustained with reputation an inaugural thesis "De Ossibus," and was then created public lecturer in the University of Bologna, and appointed reader in anatomy to the institute in that city. His excellent method of lecturing drew a crowd of auditors; and he employed his leisure in experiments and in the study of comparative anatomy. He made a number of curious observations on the urinary organs, and on the organ of hearing in birds, which were published in the Memoirs of the Institute. His reputation, as an anatomist and physiologist, was established in the schools of Italy, when accident gave birth to the discovery which has immortalized his name. His beloved wife, with whom he lived many years in the tenderest union, was at this time in a declining state of health. As a restorative, she made use of a soup of frogs; and some of these animals, skinned for the purpose, happened to lie upon a table in her husband's laboratory, upon which was placed an electrical machine. One of the assistants, in his experiments, chanced carelessly to bring the point of a scalpel near the crural nerves of a frog, lying not far from the conductor. Instantly the muscles of the limb were agitated with strong convulsions. Madame Galvani, a woman of quick understanding and a scientific turn, was present, and, struck with the phenomenon, she immediately went to inform her husband of it. He came and repeated the experiment; and soon found that the convulsion only took place when a spark was drawn from the conductor, at the time the scalpel was in contact with the nerve. It is unnecessary in this place to mention the series of experiments, by which he proceeded to investigate the law of nature, of which accident had thus given him a glimpse, for which our article Galvanism must be consulted.

In conjunction with these inquiries, his duties as a professor, and his employment as a surgeon and accoucheur, in which branches he was very eminent, gave full occupation to his industry. He drew up various memoirs upon professional topics, which have remained inedited; and regularly held learned conversations with a few literary friends, in which new works were read and commented upon. He was a man of an amiable character in private life, and possessed of great sensibility, which he had the misfortune of being called to display on the death of his wife in 1790, an event which threw him into a profound melancholy. He rarely suffered a day to pass without visiting her tomb in the nunnery of St. Catharine, and pouring out his prayers and lamentations over her remains. He was always, indeed, punctual in practising the minutest rites of his religion, the early strong impressions of which never left him; and his attachment to religion was probably the cause of steadily refusing to take the civic oath exacted by the new constitution of the Cisalpine republic, in consequence of which he incurred the deprivation of his posts and dignities. A prey to melancholy, and reduced almost to indigence, he retired to the house of his brother James,

a man of a very respectable character, and there fell into a state of languor and almost imbecility. The republican governors, probably ashamed of their conduct towards such a man, passed a decree for his restoration to his professional chair and its emoluments; but it then was too late. He died on November 5, 1798, at the age of sixty, amid the tears of his friends, and the public regret.

GALVANISM, this surprising branch of philosophy has been denominated galvanism, from Galvani, an Italian professor, whose experiments led to its discovery.

In 1789, some time before he made the most important discovery, he was by accident led to the fact, of electricity having the property of exciting contractions in the muscles of animals. Stimulated by the then prevailing idea of electricity being a principal inherent in animals, which, acting upon the muscular susceptibility, was the immediate cause of muslar motion, he was induced to persevere in the inquiry, during the prosecution of which he brought to light other facts, which laid the foundation of this valuable scientific acquisition.

After having observed that common electricity, even that of lightning, produced vivid convulsions in the limbs of recently killed animals,he ascertained that metallic substances, by mere contact, under particular circumstances, excited similar commotions.

He found that it was essential, that the forces of metals employed should be of different kinds. He applied one piece of metal to the nerve of the part, and the other to the muscle, and afterwards connected the metals, either by bringing them together, or by connecting them by an arch of a metallic substance; every time this connection was formed, the convulsions took place. The diversity in the metals employed in these experiments appeared, in the very early stages of this inquiry, to be connected with their respective degrees of oxydability, the one being possessed of that property in a great degree, and the other little liable to the change. Hence zinc, and silver, or gold, was found to produce the greatest muscular contractions.

The experiments of Galvani were confirmed by many able philosophers, by whom they were repeated. Those who particularly distinguished themselves by their labours on this subject were, Valli, Volta, Drs. Monro and Fowler.

Galvani had theorised upon the phenomena, which he had observed to a considerable extent. He conceived, that the convulsions were produced by a disturbance of the electricity inherent in animals, which was identical with the nervous fluid, and that the metallic substances employed had not any other effect, than that of transmitting the electricity from the nerve to the muscles producing the contractions in question.

Simon Volta, with much labour and ingenuity, successfully opposed the hypothesis of Galvani. He had recourse to those valuable experiments made by Bennet, by which to explain the phenomena observed by Galvani. Bennet had some time before observed, when plates of different metals were brought in contact, that one of the metals transmitted a portion of its electricity to the other, each of which, when separated, being at the same time insulated, evinced signs of contrary states of electricity. When the plates, for instance, were one of copper and the other zinc, the former, while the two were in contact, gave a portion of its electricity to the latter. Hence, when they were separated, and thus presented to the electrometer, the copper exhibited signs of negative electricity, and the zinc that of positive.

On this ground it was that Volta objected to the hypothesis of Galvani, and established the more plausible idea, that the electricity was furnished by the disturbance of that fluid, arising from the contact of the different metals, and that the convulsions were excited by the stimulating effect of that active agent. It was in the investigation of this experiment, that this truly ingenious philosopher was led to the discovery of the pile, which, from its inventor, has been called the Voltaic pile. This apparatus consisted, in combining the effects of a number of pairs of the different metals, and by that means constituting a battery in galvanism, similar in effect to the Leyden phial in common electricity.

As silver and zinc had been found in the minor experiments to produce the greatest effect, these metals were employed by Volta in the construction of his battery. The silver plates generally consisted of coins; and the zinc plates were of the same size, being frequently cast in moulds made with the silver. The same number of pieces of cloth, pasteboard, or leather, of the same size, and steeped in solution of common salt, were also provided. The above substances were formed into a pile, in the following order: zinc, silver, wet cloth; zinc, silver, wet cloth; and so on, in the same order, till the pile became sufficiently high. If it were to be elevated to any considerable height, it was usual

to support it on the sides with three pillars of glass, or varnished wood.

The pile, thus formed, was found to unite the effects of as many pairs of plates as might be employed. Previously to this, no other effect had been produced than what resulted from the energy of a single pair of plates. A pile of 50 pairs of plates, with as many corresponding pieces of wet cloth, was found to give a pretty smart shock, similar to an electric shock, every time that a communication was made between the top and bottom of the pile. It was found, however, that little or no shock was perceived, when the hands, or other parts applied, were not previously moistened. It was also observed that the effect was increased, when a larger surface was exposed to the action of the pile. If the communication were made by touching the pile with the tip of each finger merely, the effect was not perceived beyond the joint of the knuckle; but if a spoon, or other metallic substance, were grasped in moistened hands, the effect was felt up to the shoulder. If the communication be formed between any part of the face, particularly near the eyes, and another part of the body, a vivid flash of light is perceived before the eyes, corresponding with the shock. This phenomena may be more faintly observed, by placing a piece of silver, as a shilling, between the upper lip and the gum, and laying a piece of zinc at the same time upon the tongue: upon bringing the two metals in contact, a faint flash of light is perceived. It is singular, that this light is equally vivid in the dark with the strongest light, and whether the eyes be shut or open.

Another variety of galvanic battery was also contrived by Volta. The pairs of plates were soldered to each end of a bit of wire, which were afterwards bent into an arch, so that the plates became parallel to each other. A number of glass cups were also provided, and filled with a solution of culinary salt. The glasses being arranged side by side, the metallic arcs were so placed, that the silver plate was immersed into one glass, and the zinc in another; and also that a silver and zinc plate of different arcs should be placed in each glass. This arrangement was found to be similar to the pile, the water in the cups being substituted for the disks of cloth.

Soon after the discovery of the pile, in 1800, it was communicated by Volta himself to the Royal Society, London. The first experiments made in this country upon the Voltaic pile were made jointly by Messrs. Nicholson and Carlisle. After observing the phenomena already described by Volta, they observed an important fact, which had escaped the notice of that acute philosopher. When bringing the wire from the bottom of the pile, in contact with a drop of water at the top, they observed the disengagement of some gaseous substance, which had the smell of hydrogen. Supposing this effect to arise from the decomposition of the water, they caused the ends of two brass wires, coming from the two ends of the pile, to be immersed in water, so that a portion of that liquid might be exposed between the wires. A disengagement of gas immediately took place from one of the wires, while the other became as quickly tarnished, and oxydated. The former appearance took place at the silver end of the pile, the latter at the zinc end. They ascertained, that the effect would not take place when the wires were placed far asunder, and that the effect diminished gradually with the distance. They observed, also, that when the tincture of litmus was used, instead of water, the liquid in the vicinity of the oxydated wire, being that connected with the zinc end, became red. When they made use of wire of platina, instead of brass, they observed that the wire from the zinc end of the pile, which, when of brass, became oxydated, now gave out bubbles of gas, which they found to be oxygen. In short, they determined that the gases evolved were oxygen and hydrogen, and in proportions fit to constitute water. These discoveries established the chemical nature of the galvanic action in England; and they soon spread over all Europe.

The above experiments were repeated by Mr. Cruikshank, of Woolwich. He employed a glass tube, filled with water, having a cork at each end, through which wires of silver were passed, the points of which were separated from each other by a stratum of the liquid. Upon the wires being communicated with the two ends of the piles, the same appearances took place which were observed by Messrs. Nicholson and Carlisle: the silver wire, however, connected with the zinc end of the pile, became oxydated, the oxide forming a white cloud round the wire: he also, instead of water, introduced into the tube an infusion of Brazil wood. During the galvanic action, the colour in the vicinity of the wire of the zinc end became very pale, while that about the wire of the silver end of the pile appeared of a purple colour. When a metallic solu-

tion was placed in the tube, Mr. Cruickshank observed, that, instead of hydrogen gas being evolved from the wire, which connected the silver end of the pile, as in the former experiments, the metal became revived.

He next caused the galvanic current to pass through solutions of the muriates of lime and soda. In these experiments, he found the oxygen evolved from the wire of the zinc end very deficient, and a smell of oxy-muriate produced. When gold wires were employed, the gold was dissolved by the oxy-muriatic acid. Aqua ammoniæ being operated upon in a similar way, both the water and the alkali underwent decomposition, producing the gases of hydrogen, nitrogen, and oxygen.

It is to the ingenious author of the above experiments, that we are indebted for the invention of the galvanic trough, a discovery which very soon superseded the use of the pile, as being more manageable, and attended with less trouble to the operator. It consists of a wooden box, or trough, the depth and breadth of which corresponds with the size of the plates. It is of such a length, in general, as to contain fifty plates, allowing a space of about three-eighths of an inch between each pair of plates. The spaces between the plates are formed by grooves, which are to receive the plates. The plates are first soldered together in pairs, one of copper or silver, and one of zinc. The trough being lined with a cement, formed of bees'-wax and resin, the plates, which are previously warmed, are pressed into the grooves, in such order, that the zinc side of each compound-plate may face one way, and the copper or silver the other.

It will be easily perceived, that there is the strictest analogy between the trough and the pile, in point of arrangement. See fig. 1.

The pair of plates of zinc and silver, which, in the pile, are simply laid upon each other, are, in the trough, soldered together, and cemented into the grooves; and the cavity or cells formed by the spaces between each pair of plates, in the trough, being filled with a solution of salt or other appropriate liquid, stands in the stead of the pieces of moistened cloth, between the plates of the pile.

Several powerful troughs were soon after constructed, the effects of which were strikingly evinced, in producing other phenomena, not as yet observed. Very small wires and foils of metal, being exposed in their circuit, were deflagrated with great brilliancy.

A number of galvanic experiments were made by Dr. Henry, of Manchester, in which he succeeded in decomposing the sulphuric and the nitric acids, and ammonia.

Mr. Davy, professor of chemistry at the Royal Institution, made a number of experiments, the most particular of which were those, in which he ascertained, that the dissimilarity of metals was not absolutely essential to the galvanic process. He succeeded, first, in exciting this energy by means of one metal, the two sides of which were separated from each other. An oxydating liquid, such as an acid, was placed on one side of the plate, and a liquid, having a contrary effect, on the other. He afterwards produced an effect, though more faintly, by treating plates of charcoal in a similar way. Hence it would appear, from these results, that the dissimilarity of the metals was only necessary to the furnishing two surfaces of different degrees of oxydability.

Hitherto it was not generally admitted, that the fluids of galvanism and electricity were identical. Dr. Wallaston made a number of experiments, which seem to have completely settled this point. He sncceeded in decomposing water, by means of a current from the common electric machine. This effect, which had been performed with so much facility with the galvanic apparatus, was previously not known to be able to be produced by common electricity, and had hitherto appeared the most striking difference between the two principles.

This ingenious experimentalist made a number of other experiments, tending to throw much light on the means of exciting and appreciating galvanic phenomena. He immersed each extremity of a piece of zinc and silver in dilute muriatic or sulphuric acid. The zinc, as would be expected, immediately caused the disengagement of hydrogen gas, while no appearance took place upon the silver. As soon, however, as the two metals were made to touch each other at the opposite extremities, bubbles of hydrogen were copiously given out by the silver wire, Any other metal, capable of being acted upon by the acid, being substituted for the zinc, produced with the silver a similar effeet. When gold was employed with silver, iron, or copper, in the dilute nitric acid, the same effect was produced; the gold being the same with the silver in the first experiment.

He made similar experiments, using metallic solutions instead of the dilute acid. Instead, however, of silver or gold

giving out hydrogen gas, on the contact being made, the metal in solution became reduced. Thus, when iron and silver were placed in a solution of copper, the iron immediately began to reduce the copper in solution, while the silver had not the slightest action. Upon bringing the two metals in contact, however, the silver became coated with copper. Dr. Wallaston attributes the curious phenomon, above described, to a change of states in the electricity of the metals; and in order to confirm this idea, he attempted the same by means of common electricity, in which he succeeded to his utmost satisfaction. He supposes, that the chemical affinities are so altered by the presence or absence of electricity, as to induce the anomalous appearances which took place in the above experiments. The silver wire became coated with copper, and at the same time appeared to have the power of decomposing water.

The only mystery we observe in these experiments is the liberation of the hydrogen, in a situation where no oxygen is manifested, either in the form of gas, or in any other state. Nor does the new doctrine, lately advanced by Mr. Davy, throw much light on this subject. The zinc, in this experiment, is said to be positively electrified, and the copper or silver to be negative. That the zinc, on that account, attracts the oxygen of the water, and the silver the hydrogen. That the constituent parts of water are by the same law made to appear in situations where the decomposition did not take place, is very evident; hence it would appear that the hydrogen is carried by some means from the zinc to the silver; or that the oxygen passes from the silver to the zinc; or, according to Mr. Davy's hypothesis, the decomposition of the water takes place between the metals, the oxygen passing inevitably to the zinc, and the hydrogen in a similar way to the silver. To the latter there are several objections, which will appear from the following experiments.

Let a tube of three feet in length be filled with dilute muriatic acid, and corked at both ends, having a wire of zinc inserted in one end, and one of silver or platina in the other. The zinc will immediately begin to give out hydrogen, but no effect will be observed at the silver wire. Let a communication be established between the wires on the outside of the tube. The silver does not immediately give out bubbles, as was the case in the experiments of Dr. Wollaston, nor does that effect take place till a few seconds after the contact of the metals. Can we for a moment suppose that the slight negative and positive electricity produced by the contact of two small wires, which would not affect the most delicate electrometer, can have the power, the one of attracting oxygen, and the other hydrogen, at the distance of eighteen inches, reckoning from the middle of the tube?

If the same tube be bent in the middle to an acute angle, like the letter V, according to Mr. Davy's hypothesis, the appearance of the hydrogen at the silver wire ought to take place as soon after the contact, as with the straight tube; but what is very singular, it will not take place at all. This experiment would seem to prove, that one of the constituents of the water is carried through the whole length of the tube; and that by some law which differs from those of electricity, since the angle of the tube appeared to interrupt its passage. The interruption is still greater, even with a shorter tube, when the tube is bent in different places, forming a sort of zig-zag.

The idea that hydrogen is carried from the zinc to the copper-wire, is strongly favoured by another experiment. Take the glass tube A B, fig. 2, filled with dilute muriatic acid, having a cork at B, through which the wires, *z* and *c* are passed, *z* being a wire of zinc, and *c* a wire of platina, silver, or copper. So long as the wires remain unconnected at *z*, the platina-wire appears unchanged; but as soon as the contact is formed, bubbles of hydrogen are first seen at *d*; they then very slowly begin to appear in the lower parts of the wire; but what is singular, the moment they begin to appear at *f*, they are also seen at *s*, and some seconds are elapsed before any bubbles are seen at *g*. If the hydrogen in the last experiment were attracted by the negative state of the platina-wire, since the metal is the best conductor, it would seem, that the point *s* would be the last part to have parted with its electricity; and, of course, the bubbles of hydrogen ought to have appeared the last at that point, which is contrary to fact. It therefore appears more likely that the hydrogen has been held in combination by the electricity, the latter of which is taken by the nearest metallic conducter in the circuit, leaving the hydrogen in its gaseous form: the law, however, by which it moves along the liquid, does not appear to agree with any known properties of electricity, since the hydrogen is some seconds in reaching the point *g*.

It will appear from the above experiments, that the galvanic phenomena are essentially promoted, by having two metallic surfaces so situated that one shall be oxydated, and that the other shall be situated as near it as possible, for the purpose of receiving its electricity. We have shewn, that the current is not only interrupted by distance, but that it is essential the passage should be a direct line.

In Dr. Wollaston's experiments, when the wires were placed in a metallic solution, such as that of copper and silver, and the contact formed between the zinc and silver wires, no hydrogen was evolved by the latter, the contrary of which was the case with the dilute acid; but the metal in solution became reduced upon the silver.

There does not appear any thing mysterious in the reduction of the metal, since the hydrogen does not appear, being employed in the deoxydation of the metal. A further proof that this is the case is, that no other metals can be reduced in this way but such as do not decompose water. This singular process enables us to account for several facts which have hitherto appeared anomalous. If a glass plate be smeared over with a solution of nitrate of silver, and a common pin be laid in the middle of the plate, beautiful ramifications of metallic silver will soon appear, as if vegetating from the pin. If the process be examined by a magnifying glass, the ramifications of silver may be fairly seen to grow from their ends. Though the more oxydable metal, the pin, may, in the first instance, have reduced a portion of silver, it does not account for the vegetative appearance which is afterwards observed. The pin cannot reduce the silver at so great a distance from itself, which is sometimes more than an inch. In order to prove, that the agency of the oxydable metal was not essential to the reduction of the metal, the writer of this article covered one half of the plate with liquid nitrate of silver, and the other half with dilute muriatic acid, suffering the liquids to touch each other; a wire of zinc was laid in the dilute acid, and one of platina in the nitrate of silver. As soon as the opposite ends of the wires were brought in contact, beautiful ramifications of silver soon began to appear from the platina wire, but no gas was observed.

If a solution of gold be used, instead of that of silver, the platina becomes speedily gilt. The experiment producing what is called the lead-tree cannot be accounted for in any other way: it consists in filling a bottle with a solution of acetate of lead, in the upper part of which is suspended a piece of metallic zinc: in the course of a day or two, metallic lead is observed in shining filaments, suspended from the piece of zinc. The same difficulty occurs in this as in the last experiment: the filaments of lead constantly grow from the ends at a distance of many inches from the zinc. In order to prove that this experiment is similar to the last, that is, that the lead is reduced by the hydrogen, take a tube, A B, fig. 3, at one end of which tie a piece of bladder so tight that the tube may hold water; let a cork be inserted at A, through which the platina wire, P *p*, is passed; the tube being set upright in the zinc cup, D, containing dilute muriatic acid, and a connection formed at P, the platina soon becomes covered with brilliant crystals of metallic lead: hence it would appear, that the platina had the power of reducing the lead into its metallic state, or that some substance had been transmitted through the bladder adequate to that effect. If, instead of the acetate of lead, the tube be filled with dilute acid, upon the connection being formed at P, the platina becomes covered with bubbles of hydrogen: need we, therefore, hesitate in concluding, that the lead owes its reduction to the hydrogen?

The method of whitening brass and copper, by boiling them with cream of tartar and tin, is a process of this kind; the cream of tartar, and the metallic tin, answering the purpose of the zinc and acetate of lead in the last experiment: a portion of the tin in solution is reduced upon the copper or brass, rendering it white by the hydrogen which is produced during the galvanic contact of the copper or brass with the tin.

In all the experiments, the zinc wire is, during its contact with that of the platina, silver, &c. undergoing an increased oxydation, which is proportionate to the quantity of hydrogen evolved at the platina wire; since the oxygen of that and hydrogen, both of which are derived from the water, are disposed of in the oxydation of the zinc. The hydrogen passes from the zinc to the opposite wire, with the greatest facility, through a direct liquid communication, the shorter the better. It becomes much interrupted by having to turn sharp angles, or in passing through small apertures. It passes with more or less freedom through solid

bodies, when moistened with water, but does not pass at all, except when moisture is present.

Having given an account of the effects resulting from a single galvanic combination, we will next give some account of the constructions of that compound apparatus, termed Galvanic, or, more properly, the Voltaic battery.

The pile of Volta, of which we have already given a slight description, is at present so little used, that we shall direct our attention more particularly to the trough, as being more convenient for experiments than the pile, and at the same time less liable to be out of order.

The wood of which the trough is formed should be the oldest and hardest mahogany, being less liable to warp than other kinds of wood. The sides of the trough must be dove-tailed together, and the bottom ought to be grooved into the sides, and fitted in with turpentine; perpendicular grooves must be made in the sides of the trough, for the reception of the plates, correspondent to which there must be grooves in the bottom. When the length of a trough is more than two feet, it becomes unwieldly; it should not even be that length, when the size of the plates would render it too heavy to be handed about. The distance between the plates should be about three-eighths of an inch; if they are nearer together, the acid employed is too soon exhausted, and, consequently, the power of the battery less lasting.

The plates should be of copper and zinc. Though silver is stronger than copper, it is not so in proportion to the price.

The zinc plates are best cut out of sheets of malleable zinc, as being cheaper, less liable to break, and may be used much thinner.

The copper may be employed so thin as six ounces to the square foot.

The plates of copper, being made a little larger than the zinc, may be lapped over the edges of the latter, by which means they fit much closer to the zinc plate, without the labour of hammering the copper plates previously flat. The copper plates only require to be soldered to the upper edge of the zinc plate, since the other three edges are so secured with cement in the grooves as to preclude the necessity of soldering. The lapping over of the copper is sufficient to keep it close to the zinc plate till the plate is fastened in the trough. Previously to inserting the plates in the trough, the inside must be lined with a cement, formed of resin and bees-wax, or, what is cheaper, of six parts of resin and one of lime and oil. The plates, being previously warmed, are to be pressed down into the grooves before the cement becomes quite cold. After the plates have been inserted, in such order that all the zinc surfaces shall face one way and the copper the other, the cement must be more evenly adjusted with a hot iron which will reach to the bottom of the cells; the trough being laid first on one side and then on the other for that purpose.

When the cementing process is finished, and the whole sufficiently cold, the trough must be dressed off, and varnished with copal varnish, where it can be had; but in lieu of that with common spirit varnish. When the varnish is dry, it must be polished with rotten-stone and water.

In the above construction it is manifest that two of the surfaces are lost by being laid and soldered together. About two years ago the writer of this article had conceived the possibility of making use of both the surfaces of the copper and zinc plates at the same time. Accordingly he cemented into a trough, in the groove made for the plates of metal, plates of glass. The metal plates were formed by soldering together a plate of each, of copper and zinc, and then bending them till the plates became parallel to each other, leaving a space between the two surfaces a little wider than the thickness of the glass plates.

The cells between the glass plates being filled with the proper liquid, each of the above compound plates were made to bestride one of the glass plates, in such order that a zinc and copper plate of two different compound plates, in succession to each other, may occupy each of the cells. All the surfaces are by this contrivance exposed to the action of the liquid, and might be considered double the power of a common trough, having the same number of plates.

Little or no advantage was gained by this method. Though there are two surfaces of each metal in each of the cells, it will be evident, from several minor experiments already given, that two of the surfaces are so completely disconnected as to produce little or no effect. One of the zinc surfaces in this trough is facing the glass on one side the cell, and one of the copper surfaces is similarly situated on the other side.

The trough, therefore, which is represented in figure 1, and which has been

particularly described, is, for general use, the, most convenient, and in other respects, the best battery yet introduced.

The next thing to be considered, is the management of the galvanic battery. First, all of the cells of the trough must be filled, within about half an inch of the top, with a liquid, composed of water, with about one twenty-fifth part of the muriatic or the nitric acid. The plates of the trough are shorter than the depth of the trough by about three-fourths of an inch; so that the trough may be leaned on one side in the filling, for the purpose of letting the liquid run equally into all the cells.

If a number of troughs are to be connected together, the communication must be made by arcs of metal, which are inserted into the liquid of one cell of each trough, as represented in fig. 1, at C. In making the connection, it is to be observed, that the zinc surface of one trough must correspond with the copper one of another, and the zinc of the latter with copper of a third, and so on. This arrangement may be better conceived by placing them in the same order, and to end in such a way, that all the zinc surfaces may face one way, and the copper ones the other. After all the troughs are connected together, let the two unconnected ends, at which the experiments are to be made, be as near together as possible.

A connection being now formed between the two ends, one of which we shall term the zinc end, and the other the copper end, the united energy of the whole will be transmitted through the connecting medium.

EXPERIMENTS.

The most striking and the most common experiments are those which consist in the galvanic energy upon the organs of animals. If two metallic rods, or, what is equally convenient, two silver spoons, be grasped, one in each hand, the skin of the part being previously moistened with a solution of salt, and one of the spoons be brought in contact with one end of the battery, the moment the other comes in contact with the other end of the battery the shock is perceived. Fifty compound plates will give a shock which will be felt in the elbows. One of a hundred will be felt in the shoulders. A greater number of plates give so forcible a shock to the muscles, as to be dreaded a second time. The shock appears to depend upon the number of plates. The stun, or first impression, is much the same, whatever may be the size of the plates; at least, from the size of two inches square to that of ten; the surfaces being as four to one hundred. The effect upon the muscles, as well as upon the cuticle itself, is very different from large plates, when the series is the same. It appears that the shock, or first impression, is as the series, which is also as the intensity of the electricity. If the shock be received from the same number of large plates, the same species of commotion is produced, in the first instance, as with the small plates; but if the contact be still kept up, a continuation of the effect is perceived, which is felt through the whole arms, producing a vast tremor, attended with a sensation of warmth. If the plates be from eight to twelve inches square, this effect may be perpetually kept, while the acid in the cells is expended.

Though small plates have been recommended for medical purposes, we think large ones will be found more likely to have a good effect. If the medical advantage is to be derived from the stimulus of galvanism, the effect of a perpetual and regular current of that stimulus must certainly be preferable to the rapid transmission of a small quantity.

The galvanic shock may also be conveniently given, by immersing the hands or the feet into vessels containing a solution of salt, and bringing wires from each end of the battery into the liquid. If any other part of the body is intended to be operated upon, a sponge, moistened with salt water, fastened to a metal plate connected with one end of the battery, may be applied to the part, and the hand or foot put into a vessel of the same liquid, connected by a wire with the other end of the battery. Small bits of sponge or bits of leather may be fastened to the end of the connecting wires, and made more or less moist, as the delicacy of the part may require. This contrivance is very useful in operating upon the eyes or ears.

When galvanism is used medically, it should first be applied very feebly, and the effect gradually increased, as the susceptibility of the part will admit. If the part has, from disease, become so languid and insusceptible, as not to be sensible of the effect, it should be scarified, or by other means have the cuticle removed. This is sometimes the case with languid tumours, and some cases of paralysis.—

Though we had no great opinion of the medical agency of galvanism, we have lately heard of several very successful cases, one of which in particular was the cure of perfect loss of speech. If the naked metal of the wire from a powerful battery be applied to the skin, it becomes cauterized and blistered.

If the plate, covered with a moistened sponge, connected with one end of the battery, be applied to the back of the head, at the same time that the moistened fingers of one hand are slightly applied to the other end, a smarting sensation will be felt in the part, and a taste at the same time will be felt in the mouth, similar, but in a greater degree, to that occasioned by the piece of zinc and the shilling when laid upon the tongue. This experiment succeeds the best with a small number of large plates, as much as ten inches square.

Decomposition of Water and other Bodies.

The most simple way of performing this experiment is, to bring the wires coming from each end of the battery into a vessel of water. A profusion of bubbles of gas will appear to be given out from each wire, as far as they are immersed in the liquid. The nearer the wires are brought together, so as not to touch, the more rapidly the decomposition goes on. The gas produced from the wire coming from the zinc end of the battery, if the wire be of gold or platina, is found to be oxygen gas; but if the wire be of any more oxydable metal, no gas will appear, but the wire becomes oxydated. The gas furnished by the wire from the copper end of the battery, or whatever kind of metal the wire may be, is pure hydrogen. If the immersed part of this, however, be previously oxydated, no gas will be observed for some time, the hydrogen being employed in reducing the oxide upon the surface.

Both the gases are furnished from the decomposition of the water.

An apparatus more convenient for this experiment, and at the same time fitted for collecting the gases, is shown in fig. 4; *c g*, is a cup of glass capable of receiving the glass tube, *h*; E *c*, and *f z*, are two wires of platina, fitted into two holes perforated in the bottom of the glass cup; the tube, *h*, which is close at the top, is first filled with the water or other liquid, and the cup inverted upon it; the whole are then suddenly returned into their erect position. This apparatus is then placed in the frame, fig. 5; A B C D are four pieces of brass, united together by the pieces of glass, F and G, and supported by four legs, through which also the brass rods, H and K, are passed. It is plain, the two sides of this frame are insulated with respect to each other, at least as much as is necessary for any galvanic experiment. The part *f*, in fig. 4, being introduced into any of the holes, such as *n m*, the opposite end, F, is made to rest on the opposite brass rod, K. If the wires from the battery be now connected with the frame at H and K, the gass will instantly begin to rise from the wires, *c* and *z*, up into the tube, while the liquid descends and occupies the cup.

A number of the apparatus, such as fig. 4, may be employed at the same time; and if the different tubes are filled with different liquids, such as the various solutions of salts, and the communication of each occasionally cut off, by placing some non-conductor at E, their relative conducting powers may be ascertained.

If two tubes of smaller size be placed, one over the wire, *z*, and the other over that of *c*, the gases may be collected separately.

If the tube contains a metallic solution, such as silver, lead, or copper, the wire from the copper end of the battery will afford no gas; but the metal of the solution will be reduced. Let the glass vessel A, fig. 6, have the two tubes, *z* and *c*, ground into its two necks. At the ends, *z* and *c*, of the tubes, are tied bits of bladder, so that any liquid in the tubes may have no tendency to enter the vessel A. The vessel being previously filled with some liquid, the tubes are so inserted that no air may exist between the ends of the tubes; the tubes are also provided with two small caps of ivory or wood, through which the platina wires, *p p*, are passed, reaching the bottom so near as not to pierce the bladders. The tubes being filled with water, and the wire from the zinc end of the battery connected with the wire of tube *z*, while that of the copper is attached to that of tube *c*, the decomposition of water will speedily commence, the wire in *z* affording oxygen gas, while that of *c* affords hydrogen gas. In a very short time, the liquid of the tube *z* will be found to contain muriatic acid; or, rather, the oxymuriatic; and the tube, *c*, will at the same time be found to con-

tain a fixed alkali. If the tubes be filled with infusion of cabbage, the signs of alkali and acid are very soon observed, from the liquid of *z* becoming red, and that of *c* green. If the connection be reversed, the liquids repass to the blue colour, and if the process be continued, that of *z* becomes green, and *c* red.

Galvanism, as a source of light and heat.

Batteries of great dimensions, such as contain from 5,000 to 10,000 square inches each, of zinc and copper surface, are capable of furnishing abundance of sensible heat and much light. If the connection between the two ends of the battery be made by a very small wire, such as the fine watch spring wire, the wire becomes red-hot for a considerable length, and if the power of the battery be great, it becomes white-hot, and ultimately fused.

Let the end of the wires of the battery be each provided with a pair of tweezers, one pair of which being insulated from the hand by covering the surface with dry cloth; place between each pair of tweezers a small bit of charcoal, made in a close vessel, from box-wood, or lignum vitæ. The moment the contact is formed between the bits of charcoal, a vivid light is produced, much more brilliant than that occasioned by burning in oxygen. If the contact be frequently severed by a sort of tremulous motion, the light may be kept up for some time.

The foils and small wires of metals are deflagrated by placing them in the current. Let one of the conducting wires be brought in contact with an iron dish, filled with mercury. Let the foil or small wires be attached to the other conducting wire, and be brought in contact with the surface of the mercury, which, constantly presenting a clear surface, is very convenient in these experiments. A very brilliant effect may also be produced, by presenting the foils to the surface of a sheet of tinsel.

In flaming oils, alcohol, &c. by galvanism, some thin metallic substance, or a small piece of charcoal, should be covered with the substance to be inflamed. The moment the contact is made, as in deflagrating the metal, the oil takes fire.

The galvanic spark, with great facility, fires a mixture of oxygen and hydrogen gases.

A very brilliant discovery has lately been made by Mr. Davy, Professor at the Royal Institution, and confirmed by others, which consists in the decomposition of the two fixed alkalies. It is performed by placing a bit of the alkali in the solid state, and a little moistened, upon a plate of platina, connected with one end of the battery, and bringing into contact with it another piece of platina, from the other end of the battery. A portion of black matter is soon formed, in which is found imbedded small metallic globules; which substance is found to be the base of the alkali, and has been deprived of its oxygen by the galvanic agency. These globules are so inflammable, as to decompose water, with a brilliant flash and slight explosion. See Alkali.

This discovery will be of great importance to chemistry, and will probably soon make a serious change in its arrangement and nomenclature.

GAMBOGE, is a substance obtained from the stalagmites cambogioides, a tree that grows wild in the East Indies; from which it is had by wounding the shoots, It is brought here in large cakes, which are yellow, opaque, and brittle. With water it forms a yellow turbid liquid used in painting. In alcohol it is completely dissolved. If taken internally, it operates violently as a cathartic.

GAME. It is a maxim of the common law, that goods of which no person can claim any property belong to the King by his prerogative; hence those animals feræ naturæ, which come under the denomination of game, are styled his Majesty's game; and that which he has he may grant to another; in consequence of which, another may prescribe to have the same within such a precinct or lordship. And hence originated the right of lords of manors, or others, to the game within their respective liberties. For the preservation of these species of animals, for the recreation and amusement of persons of fortune, to whom the King has granted the same, and to prevent persons of inferior rank from misemploying their time, the following acts of parliament have been made. The common people are not injured by these restrictions, no right being taken from them which they ever enjoyed; but privileges are granted to those who have certain qualifications therein mentioned, which before rested solely in the King. To entitle any one to kill game, he must now take out a certificate, upon which a stamp duty is payable. These certificates are to be dated the day of the month when issued,

and shall be in force till the first of July following, and no longer; and if any clerk of the peace, his deputy, or steward, clerk, &c. issue certificates otherwise than directed, to forfeit 20*l.* 25 Geo. III. sess. 2. No person to destroy game, until he has delivered an account of his name and place of abode to the clerk of the peace, or his deputy, or to the sheriff, or steward, clerk of the county, riding, shire, stewartry, or place where such person shall reside, and annually take out a certificate thereof, which must have a stamp duty of 3*l.* 3*s.* 25 Geo. III. sess. 2. Any person counterfeiting or forging any seal or stamp directed to be used by this act, with intent to defraud the revenue, or shall utter or sell such counterfeit, on conviction thereof, shall be adjudged a felon, and shall suffer death without benefit of clergy; and all provisions of former acts relative to stamp duties to be in force in executing this act. 25 Geo. III. sess. 2. Every qualified person, shooting at, killing, taking, or shooting, any pheasant, partridge, heath-fowl, or black-game, or any grouse or red game, or any other game, or killing, taking, or destroying any hare, with any greyhound, hound, pointer, spaniel, setting-dog, or other dog, without having obtained such certificate, shall forfeit the sum of 20*l.* *Id.* Clerks of the peace, or their deputies, or the sheriff, or steward-clerks, in their respective counties, ridings, shires, stewartries, or places, shall, on or before November 1, 1785, or sooner, if required by the commissioners of his Majesty's stamp duties, transmit to the head office of stamps in London, a correct list, in alphabetical order, of the certificates by them issued between the 25th day of March in the year 1785, and the first of October in the same year; and shall also in every subsequent year, on or before the first of August in each year, make out and transmit to the stamp office in London, correct alphabetical lists of the certificates so granted by them, distinguishing the duties paid on each respective certificate so isused; and on delivery thereof, the receiver-general of the stamp duties shall pay to the clerk of the peace, &c. for the same, one halfpenny a name; and in case of neglect, or refusal, or not inserting a full, true and perfect account, he shall forfeit 20*l.* *Id.* Lists may be inspected at the stamp office for 1*s.* each search; (*id.*) which list shall once, or oftener, in every year, be inserted in the newspapers in each respective county. If any qualified person, or one having a deputation, shall be found in pursuit of game, with gun, dog, or net, or other engine for the destruction of game, or taking or killing thereof, and shall be required to show his certificate, by the lord or lady of the manor, or proprietor of the land whereon such person shall be using such gun, &c. or by any duly appointed gamekeeper, or by any qualified or certified person, or by any officer of the stamps, properly authorised by the commissioners, he shall produce his certificate: and if such person shall refuse, upon the production of the certificate of the person requiring the same, to show the certificate granted to him for the like purpose; or in case of not having such certificate to produce, shall refuse to tell his christian and surname, and his place of residence, and the name of the county where his certificate was issued, or shall give in any false or fictitious name, he shall forfeit 50*l.* *Id.* Certificates do not authorize any person to shoot at, kill, take, or destroy, any game, at any time that is prohibited by law, nor give any person a right to shoot at, &c. unless he be duly qualified by law. *Id.* No certificate obtained under any deputation shall be pleaded or given in evidence, where any person shall shoot at, &c. any game out of the manors or lands for which it was given. The royal family are exempted from taking out certificates for themselves or their deputies. *Id.* The duty on these certificates are now, by an act which is at present passing the house, to be had through the collectors of the assessed taxes. The above is the law now in force. Besides having a certificate, each person to kill game must be qualified by having a certain estate. The last general qualification (to use the words of Dr. Burn, though in fact it is the first of the acts relative to the game ever now put in force,) by estate or degree, to kill game, is 22, 23 Charles II. c. 25. This enacts, that every person not having lands or tenements of the clear yearly value of 100*l.* or on leases for 99 years, or upwards, of the clear yearly value of 150*l.* or except the eldest son and heir of an esquire or person of higher degree, or owners of forests, parks, &c. in respect of such forest, park, &c. is not qualified for himself, or any other person, to keep guns, bows, greyhounds, &c. s. 3. This merely states the qualification; the penalties and modes of proceeding are entirely changed by subsequent acts: and first, by 5 Anne, c. 14, which directs that all former acts not thereby repealed and altered continue in force. With respect to offences against the game laws, we shall here enumerate

those chiefly which fall under the cognizance of justices of the peace out of sessions, premising, that for brevity sake the following abbreviations are used; *viz.* P. denotes the penalty; R. the mode of recovery; A. the application of it; Ap. the appeal; J. 1 or 2, and W. 1 or 2, that one or two justices may convict, or that one or two witnesses must prove the offence: and in treating of the several statutes on this head, we shall consider, 1. what relates to game exclusively; 2. what relates to other quadrupeds; and, 3. other birds, which, though feræ naturæ, are sometimes reclaimed, and private property.

Every higler, chapman, victualler, carrier, &c. who shall have in his possession any hare, pheasant, partridge, moor-game, &c. or offer to sell any such (except sent by a person qualified to kill game,) P. *5l.* for each piece; R. distress, and in default, commitment three months; J. 1. Stat. 5. Ann, c. 14, s. 2.

Persons not qualified to keep dogs, engines, &c. to destroy game, P. *5l.*; R. as above; A. half to the informer, half to the poor. Justices, lords of manors, and game-keepers, may take away the game, dogs, guns, &c.

Game-keeper selling, or otherwise disposing of such game, without consent of the lord of the manor, P. three months imprisonment; conviction as above. *Ibid.* s. 4.

Killing game in the night, *i. e.* between seven in the night and six in the morning, from October 12 to February 12; and between nine at night and six in the morning, from Feb. 12 to Oct. 12; or at any time on a Sunday or Christmas Day, P. from 10*l.* to 20*l.* for the first offence, and from 20*l.* to 30*l.* for the second; conviction as above, to be within one month. 13 Geo. III. c. 80, s. 1, 2, 3, 9. In case of a third offence, P. commitment to the session, unless he become bound with two sureties to appear; prosecutor to be bound to prosecute (*ibid.* s. 1.;) application of penalties, half to the informer, half to the poor; R. distress, and in default, commitment three calendar months. Ap. sessions. *Ibid.* s. 4.

More than two persons going out with guns, nets, &c. to destroy game, between eight at night and six in the morning, from Oct. 1 to Feb. 1; or between ten at night and four in the morning, between Feb. 1 and Oct. 10; or any person found with fire-arms or other weapons; may be apprehended by owners, keepers, &c. who shall deliver them to a peace-officer, to be taken before a justice; or if they cannot be apprehended, the justice, on information on oath, may issue his warrant; P. deemed a rogue and vagabond, and to suffer accordingly. 39, 40 Geo. III. c. 50.

Killing, or having in possession, any partridge, between Feb. 1 and Sept. 1, or any pheasant, between Feb. 1 and Oct. 1, P. *5l.* for each bird; R. action in the courts of Westminster. 2 Geo. III. c. 19.

Killing, or having in possession, any black-game, from Dec. 10 to Aug. 20, (in New Forest, from Dec. 10 to Sept. 1, by 43 Geo. III. c. 34;) or any red game, from Dec. 10 to Aug. 12; or bustard, from March 1 to Sept. 1: P. 10*l.* to 20*l.* first offence, and 20*l.* to 30*l.* for every subsequent offence; R. distress and sale, if not forthwith paid, and the offender may be detained till the return of the distress, unless he gives security to appear again in five days; for want of distress, commitment from three to six calendar months, or till paid with costs; J. 1; W. 1; A. half to the informer, half to the poor; Ap. sessions, to be holden within four calendar months after the cause of complaint, giving fourteen days notice to the justice, and every other person concerned, and entering into recognizance, with one sufficient surety, to try the appeal, and abide the order of the court. 13 Geo. III. c. 55, s. 1, 2, 3, 4, 9, 10.

Every person using gun, dog, &c. to destroy the game, must take out a certificate from the clerk of the peace, for which he shall pay a duty of 3*l.* 3*s.* P. 20*l.* R. J. 1, W. 1. distress, or in default, commitment three calendar months, or till paid. A. half to the informer, half to the King. But if not prosecuted within six calendar months, the whole to the King. Ap. sessions. Justice may mitigate, not to less than half and costs. Gamekeeper to take out a certificate, for which he shall pay 1*l.* 1*s.*; under the same regulations and penalties, 25 Geo. III. c. 5. 31 Geo. III. c. 21.

Killing, or attempting to kill, any deer, in any forest, chase, or park, without consent of the owner, P. 20*l.*; and for every deer killed or carried away, 30*l.*; and if the offender be a keeper, double. R. sessions. Conviction, J. 1, who shall transmit the conviction to the sessions. 16. Geo. III. c. 30, s. 1, 3. Justice, on oath W. 1, may issue his warrant to search for any deer-skin, head, &c. or any net, and cause the person on whose premises they are found to be brought before him, and if he does not give a satisfactory account how he came by them, P. from 10*l.* to 30*l.* *Ibid.* s. 4. Persons through whose hands the deer, &c. have passed, not giving a good account, liable to the same penalties. *Ibid.*

s. 5. Keepers and their assistants may apprehend offenders they find in the act, and take them before a justice. *Ibid.* c. 15. R. distress, and for want of distress, commitment for six months, or till paid, with costs, J. 1. W. 1. A. half to the King, half to the informer. *Ibid.* s. 11.

Burning furze, fern, &c. on any forest or chase without consent of the owner, keeper, &c. P. 40*s*. to 5*l*. R. distress, or in default, commitment from one to three months. J. 1. W. 1. A. half to the informer, half to the poor. 28 George II. c. 19.

Unlawfully entering into any ground, (enclosed or not,) and hunting or killing rabbits, P. treble damages to the party aggrieved and costs, or commitment for three months, and till he find sureties for his good behaviour. J. 1. W. 1. 22, 23, Charles II. c. 25, s. 4.

Killing or taking house-dove or pigeon, P. 20*s*. or commitment from one to three calendar months, or till paid. R. J. 1. W. 1. A. to the prosecutor, 2 George III. c. 29.

Driving, or taking by nets, tunnels, &c. any water-fowl in the moulting season, P. 5*s*. for each fowl, and nets to be seized and destroyed. R. distress, and in default, commitment from fourteen days to one month. J. 1. W. 1. A. half to the informer, half to the poor. 9 Anne, c. 25. s. 4.

Game, are deer, hares, pheasants, partridges, moor game, and, by the act now passing, snipes and woodcocks are made game.

It is not to be inferred that these statutes actually impower qualified persons to hunt or shoot any where. They cannot enter another man's land in pursuit of game without his leave; but at the same time, if he has not warned the sportsman against coming upon his land, he will not recover more than 40*s*. costs in an action of trespass.

Sporting seasons. The time for sporting, in the day, is from one hour before sun rising, until one hour after sun setting. 10 George III. c. 19. For bustards, the sporting is from December 1, to March 1. For grouse, or red grouse, from August 11, to December 10. Hares may be killed all the year, under the restrictions in 10 George III. c. 19. Heath-fowl, or black-game, from August 20, to December 20. Partridges, from September 1, to February 12. Pheasants, from October 1, to February 1. Widgeons, wild ducks, wild geese, wild fowls, at any time but in June, July, August, and September.

GAMING, *laws of.* These are founded on the doctrine of chances. See CHANCE.

M. de Moivre, in a treatise "De Mensura Sortis," has computed the variety of chances in several cases that occur in gaming, the laws of which may be understood by what follows:

Suppose p the number of cases in which an event may happen, and q the number of cases wherein it may not happen, both sides have the degree of probability, which is to each other as p to q.

If two gamesters, A and B, engage on this footing, that, if the cases p happen, A shall win; but if q happen, B shall win, and the stake be a; the chance of A will be $\frac{pa}{p+q}$, and that of B $\frac{qa}{p+q}$; consequently, if they sell the expectancies, they should have that for them respectively.

If A and B play with a single die, on this condition, that, if A throw two or more aces at eight throws, he shall win; otherwise B shall win; what is the ratio of their chances? Since there is but one case wherein an ace may turn up, and five wherein it may not, let $a = 1$, and $b = 5$. And again, since there are eight throws of the die, let $n = 8$; and you will have $\overline{a+b}|^{n} - b^{n} - n\,a\,b - 1$, to $b^{n} + n\,a\,b^{n-1}$: that is, the chance of A will be to that of B, as 663,991 to 10,156,525, or nearly as 2 to 3.

A and B are engaged at single quoits, and, after playing some time, A wants 4 of being up, and B 6; but B is so much the better gamester, that his chance against A upon a single throw would be as 3 to 2; what is the ratio of their chances? Since A wants 4, and B 6, the game will be ended at nine throws; therefore raise $a+b$ to the ninth power, and it will be $a^9+9a^8\,b+36\,a^7\,b\,b+84\,a^6\,b^3+126\,a^5\,b^4+126\,a^4\,b^5$, to $84\,a^3\,b^6+36\,a\,a\,b^7+6\,a\,b^3+b^9$ · call a 3, and b 2, and you will have the ratio of chances in numbers, *viz.* 1,759,077 to 194,048.

A and B play at single quoits, and A is the best gamester, so that he can give B 2 in 3; what is the ratio of their chances at a single throw? Suppose the chances as z to 1, and raise $z+1$ to its cube, which will be $z^3+3\,z^2+3\,z$

$+ 1$. Now since A could give B 2 out of 3, A might undertake to win three rows running; and, consequently, the chances in this case will be as z^3 to $3 z^2 + 3 z + 1$. Hence, $z^3 = 3 z^2 + 3 z + 1$; or, $2 z^3 = z^3 + 3 z^2 + 3 z + 1$. And, therefore, $z \sqrt[3]{2} = z + 1$; and, consequently, $z = \frac{1}{\sqrt[3]{2}-1}$. The chances therefore, are $\frac{1}{\sqrt[3]{2}-1}$, and 1, respectively.

Again, suppose I have two wagers depending, in the first of which I have 3 to 2 the best of the lay, and in the second, 7 to 4, what is the probability I win both wagers?

1. The probability of winning the first is $\frac{3}{5}$, that is, the number of chances I have to win divided by the number of all the chances: the probability of winning the second is $\frac{7}{11}$. therefore, multiplying these two fractions together, the product will be $\frac{21}{55}$, which is the probability of winning both wagers. Now, this fraction being subtracted from 1, the remainder is $\frac{34}{55}$ which is the probability I do not win both wagers: therefore the odds against me are 34 to 21.

2. If I would know what the probability is of winning the first, and losing the second, I argue thus: the probability of winning the first is $\frac{3}{5}$, the probability of losing the second is $\frac{4}{11}$: therefore, multiplying $\frac{3}{5}$ by $\frac{4}{11}$, the product $\frac{12}{55}$ will be the probability of my winning the first, and losing the second; which being subtracted from 1, there will remain $\frac{43}{55}$, which is the probability I do not win the first, and at the same time lose the second.

3. If I would know what the probability is of winning the second, and at the same time losing the first, I say thus: the probability of winning the second is $\frac{7}{11}$; the probability of losing the first is $\frac{2}{5}$; therefore, multiplying these two fractions together, the product $\frac{14}{55}$ is the probability I win the second, and also lose the first.

4. If I would know what the probability is of losing both wagers, I say, the probability of losing the first is $\frac{2}{5}$, and the probability of losing the second $\frac{4}{11}$; therefore, the probability of losing them both is $\frac{8}{55}$; which being subtracted from 1, there remains $\frac{47}{55}$; therefore, the odds of losing both wagers is 47 to 8.

This way of reasoning is applicable to the happening or failing of any events that may fall under consideration. Thus, if I would know what the probability is of missing an ace four times together with a die, this I consider as the failing of four different events. Now the probability of missing the first is $\frac{5}{6}$, the second is also $\frac{5}{6}$, the third $\frac{5}{6}$, and the fourth $\frac{5}{6}$; therefore the probability of missing it four times together is $\frac{5}{6} \times \frac{5}{6} \times \frac{5}{6} \times \frac{5}{6} = \frac{625}{1296}$; which being subtracted from 1, there will remain $\frac{671}{1296}$ for the probability of throwing it once or oftener in four times; therefore the odds of throwing an ace in four times, is 671 to 625.

But if the flinging of an ace was undertaken in three times, the probability of missing it three times would be $\frac{5}{6} \times \frac{5}{6} \times \frac{5}{6} = \frac{125}{216}$: which being subtracted from 1, there will remain $\frac{91}{216}$ for the probability of throwing it once or oftener in three times; therefore the odds against throwing it in three times are 125 to 91. Again, suppose we would know the probability of throwing an ace once in four times, and no more: since the probability of throwing it the first time is $\frac{1}{6}$, and of missing it the other three times is $\frac{5}{6} \times \frac{5}{6} \times \frac{5}{6}$, it follows that the probability of throwing it the first time, and missing it the other three successive times, is $\frac{1}{6} \times \frac{5}{6} \times \frac{5}{6} \times \frac{5}{6} = \frac{125}{1296}$; but because it is possible to hit it every throw as well as the first, it follows, that the probability of throwing it once in four throws, and missing the other three, is $\frac{4 \times 125}{1296} = \frac{500}{1296}$; which being subtracted from 1, there will remain $\frac{796}{1296}$ for the probability of throwing it once, and no more, in four times: therefore, if one undertake to throw an ace once, and no more, in four times, he has 500 to 796 the worst of the lay, or 5 to 8 very near.

Suppose two events are such, that one of them has twice as many chances to come up as the other, what is the probability that the event, which has the greater number of chances to come up, does not happen twice before the other happens once, which is the case of flinging 7 with two dice before 4 once? Since the number of chances are as 2 to 1, the

probability of the first happening before the second is $\frac{2}{3}$, but the probability of its happening twice before it, is but $\frac{2}{3} \times \frac{2}{3}$ or $\frac{4}{9}$; therefore it is 5 to 4 seven does not come up twice before four once.

But if it were demanded what must be the proportion of the facilities of the coming up of two events, to make that which has the most chances come up twice, before the other comes up once: The answer is 12 to 5 very nearly; whence it follows, that the probability of throwing the first before the second is $\frac{12}{17}$, and the probability of throwing it twice is $\frac{12}{17}$, $\times$ $\frac{12}{17}$, or $\frac{144}{289}$; therefore the probability of not doing it is $\frac{145}{289}$: therefore the odds against it are, as 145 to 144, which comes very near an equality.

Suppose there is a heap of thirteen cards of one colour, and another heap of thirteen cards of another colour, what is the probability, that, taking one card at a venture out of each heap, I shall take out the two aces?

The probability of taking the ace out of the first heap is $\frac{1}{13}$, the probability of taking the ace out of the second heap is $\frac{1}{13}$; therefore the probability of taking out both aces is $\frac{1}{13} \times \frac{1}{13} = \frac{1}{169}$, which being subtracted from 1, there will remain $\frac{168}{169}$: therefore the odds against me are 168 to 1.

In cases where the events depend on one another, the manner of arguing is somewhat altered. Thus, suppose that out of one single heap of thirteen cards of one colour, I should undertake to take out first the ace; and, secondly, the two: though the probability of taking out the ace be $\frac{1}{13}$, and the probability of taking out the two be likewise $\frac{1}{13}$; yet the ace being supposed as taken out already, there will remain only twelve cards in the heap, which will make the probability of taking out the two to be $\frac{1}{12}$; therefore the probability of taking out the ace, and then the two, will be $\frac{1}{13} \times \frac{1}{12}$.

In this last question the two events have a dependence on each other, which consists in this, that one of the events being supposed as having happened, the probability of the other's happening is thereby altered. But the case is not so in the two heaps of cards.

If the events in question be n in number, and be such as have the same number a of chances by which they may happen, and likewise the same number b of chances by which they may fail, raise $a + b$ to the power n. And if A and B play together, on condition that if either one or more of the events in question happen, A shall win, and B lose, the probability of A's winning will be $\frac{\overline{a+b}|^n - b^n}{\overline{a+b}|^n}$; and that of B's winning will be $\frac{b^n}{\overline{a+b}|^n}$; for when $a + b$ is actually raised to the power n, the only term in which a does not occur is the last $b\ n$; therefore all the terms but the last are favourable to A.

Thus, if $n = 3$, raising $a + b$ to the cube $a^3 + 3\,a^2\,b + 3\,a\,b^2 + b^3$, all the terms but b^3 will be favourable to A; and therefore the probability of A's winning will be $\frac{a^3 + 3\,a^2\,b + 3\,a\,b^2}{\overline{a+b}|^3}$, or $\frac{\overline{a+b}|^3 - b^3}{\overline{a+b}|^3}$; and the probability of B's winning will be $\frac{b^3}{\overline{a+b}|^3}$. But if A and B play on condition that, if either two or more of the events in question happen, A shall win; but in case one only happen, or none, B shall win; the probability of A's winning will be $\frac{\overline{a+b}|^n - n\,a\,b^{n-1} - b^n}{\overline{n+b}|^n}$; for the only two terms in which $a\,a$ does not occur are the two last, *viz.* $n\,a\,b^{n-1}$ and b^n. See Simpson's "Nature and Laws of Chance." We shall now add a table that may be useful to persons not skilled in mathematics, and which is applicable to many subjects:

TABLE,

Showing the Odds of Winning in any Game, when the number of Games wanting does not exceed Six, and the Skill of the Contenders is equal.

Games wanting.	Odds of winning.	Games wanting.	Odds of winning.	Games wanting.	Odds of winning.
1, 2 . . .	3 : 1	2, 3 . .	11 : 5	3, 5 ..	99 : 29
1, 3 . . .	7 : 1	2, 4 . .	26 : 6	3, 6 ..	219 : 37
1, 4 . .	15 : 1	2, 5 . .	57 : 7	4, 5 ..	163 : 93
1, 5 . .	31 : 1	2, 6 .	120 : 8	4, 6 ..	382 : 130
1, 6 . .	63 : 1	3, 5 . .	42 : 22	5, 6 ..	638 : 386

The above proportions are found by the binomial theorem in a very easy way. Suppose the games wanting 1 and 5, raise $a+b$ to the fifth power, being the number of games which must determine the bet. $a=b$ in this case, as the skill is equal: $a^5+5, a^4\,b+19, a^3\,b^2+10, a^2\,b^3+5, a\,b^4+b^5$, the first five coefficients are the chances of him who has 1 game to get, *viz.* $1+5+10+10+5=31$, and the other, *viz.* 1, the chance of him who has five to get.

Suppose the games wanting are 2 and 5, then $a^6+6, a^5\,b+15, a^4\,b^2+20, a^3\,b^3+15, a^2\,b^4+6, a\,b^5+b^6$, the chances for him wanting two are $1+6+15+20+15=57$; but for him wanting 5, are $6+1=7$ according to table $57:7$.

Suppose the games wanting 4 and 6, then $a^9+9, a^8\,b+36, a^7\,b^2+84, a^6\,b^3+126, a^5\,b^4+126, a^4\,b^5+84, a^3\,b^6+36, a^4\,b^7+9, a\,b^8+b^9$; therefore for him wanting 4 games, $1+9+36+84+126+126=382$, and to him wanting 6 are $84+36+9+1=130$: the odds are $382:130$ according to table.

When the skill is not equal, or when the chances for winning are not equal: as,

1. If A and B play together, and A wants 1 game of being up, and B wants 2; but the chances whereby B may win a game are double to the number of chances whereby A may win the same. Here the number of games are two. And $a=1$ and $b=2 \therefore a^2+2\,a\,b+b^2$ will give the probability of each. $A=1+4=5$ and $B=4$ or the probabilities are $A:B::5:4$.

2. A wants 3 games of being up, B 7; the proportion of chances 3 to 5, what is the proportion of chances to win the set? here the number of games will be 9, $a=3\ b=5$, therefore raise $\overline{a+b})^9$ and the three last terms $\div$ by $a+b^9$ will express the chances of B, which subtracted from unity gives the chances of A: thus,

$a^9+9, a^8\,b+35, a^7\,b+84, a^6\,b^3+126, a^5\,b^4+126, a^4\,b^5+84, a^3\,b^6+36, a^2\,b^7+9, a\,b^8+b^9$.

$$B=\frac{\overline{5}|^9+27\times\overline{5}|^8+324\times\overline{5}|^7}{\overline{8}|^9}=\frac{\overline{5}|^7\times\overline{25+27.5+324}}{\overline{8}|^9}=\frac{37812500}{134217728}.$$

GAMMONING, among seamen, denotes several turns of rope taken round the bowsprit, and reeved through holes in knees of the head, for the greater security of the bowsprit.

GAMMUT, Gam, Gamma, or Gammaut, in music, a scale, whereon we learn to sound the musical notes, *ut*, *re*, *mi*, *fa*, *sol*, *la*, in their several orders and dispositions.

GANG, in sea affairs, a select number of a ship's crew appointed on any particular service, and commanded by an officer suitable to the occasion.

Gang *board*, is a plank with several steps nailed to it, for the convenience of walking into or out of a boat upon the shore, where the water is not deep enough to float the boat close to the landing place.

Gang *way*, a narrow platform, or range of planks, laid horizontally along the upper part of a ship's side, from the quarter-deck to the forecastle, and is peculiar to ships that are deep waisted, for the convenience of walking more expeditiously fore and aft than by descending into the waist: it is fenced on the outside by iron stanchions, and ropes or rails, and in vessels of war with a netting, in which part of the hammocks are stowed. In merchantmen, it is frequently called the gang-board. The same term is applied to that of a ship's side,

both within and without, by which persons enter and depart; it is provided with steps nailed upon the ship's-side, nearly as low as the surface of the water, and sometimes furnished with a railed accommodation ladder.

GANTLOPE, in sea affairs, commonly pronounced gantlet, is a race which a criminal is sentenced to run in a vessel of war for felony, or some other heinous offence. The whole ship's crew is disposed in two rows, standing face to face on both sides the deck, each person being furnished with a small twisted cord, having two or three knots in it; the delinquent is then stripped naked above the waist, and obliged to pass forward between the two rows a certain number of times, rarely exceeding three, during which every person is enjoined to give him stripes as he runs along: this is called "running the gantlet," and is seldom inflicted but for crimes which excite general antipathy among the seamen.

GAOL, gaols cannot now be erected by any less authority than an act of parliament. All prisons and goals belong to the King, although a subject may have the custody, or keeping of them. The justices of the peace at their general quarter-sessions, or the major part of them, not less than seven, upon presentment made by the grand jury at the assizes, of the insufficiency, inconveniency, or want of repair of the gaol, may contract for the building, repairing, or enlarging it, &c. or for erecting any new gaol within any distance not exceeding two miles from the scite, and in that case for selling the old gaol and its scite, the contractors giving security to the clerk of the peace for the performance of the contract. 24 George III. c. 54. The expenses to be paid out of, and in certain cases money may be raised by mortgage upon, the county-rate.

As there are several persons confined in the county and city gaols, under sentence, and orders made by one or more justices at their sessions or otherwise, upon conviction in a summary way, without the intervention of a jury; it is by 24 George III. c. 56, enacted, that any judge of assize, or two justices, within whose jurisdiction such gaol is situate, may remove such persons to any house of correction within the same jurisdiction, there to be confined, and to remain in execution of such sentence or order.

For the relief of prisoners in gaols, justices of the peace, in sessions, have power to tax every parish in the county, not exceeding 6*s.* and 8*d.* per week, leviable by constables, and distributed by collectors, &c. 12 Charles II. c. 29. But it is observed by Lord Coke, that the gaoler cannot refuse the prisoner victuals, for he ought not to suffer him to die for want of sustenance. If any subject of this realm shall be committed to any prison, for any criminal, or supposed criminal matter, he shall not be removed from thence, unless it be by habeas corpus, or some other legal writ; or where he is removed from one prison or place to another, within the same county, in order to his trial or discharge; or in case of sudden fire, or infection, or other necessity: on pain that the person signing any warrant for such removal, and he who executes the same, shall forfeit to the party grieved, 100*l.* for the first offence, and 200*l.* for the second. Justices at sessions make regulations for the gaols of the county, and there are statutes forbidding the selling of spirits, or secretly conveying them into gaols.

Gaol *delivery*, by the law of the land, that men might not be long detained in prison, but might receive full and speedy justice, commissions of gaol delivery are issued out, directed to two of the judges, and the clerk of assize, associated; by virtue of which commission, they have power to try every prisoner in the gaol, committed for any offence whatsoever. This is one of the commissions by which the judges sit at every assize.

It is a frequent question, what can be given in evidence by the defendant upon this plea, and the difficulty is to know, when the matter of defence may be urged upon the general issue, or must be specially pleaded upon the record. In many cases, for the protection of justices, constables, excise-officers, &c. they are, by act of parliament, enabled to plead the general issue, and give the special matter for their justification under the act in evidence.

GARBOARD *strake*, the plank next the keel of a ship, one edge of which is run into the rabbit made in the upper edge of the keel on each side.

GARCINA, in botany, so named in honour of Laurent Garcin, M. D. F. R. S. a genus of the Dodecandria Monogynia class and order. Natural order of Bicornes, Linnæus. Guttiferæ, Jussieu. Essential character: calyx four-leaved, inferior; petals four; berry eight-seeded, crowned with the peltate stigma. There are three species.

GARDANT, or Guardant, in heral-

dry, denotes any beast full faced, and looking right forward.

GARDEN. We must divide this article under four heads; *viz.* the flower, or pleasure garden, the kitchen garden, the nursery, and the forcing department. Of these we shall treat distinctly under the head of GARDENING.

In this place it is proper to state, that a garden should have a favourable aspect, gently declining towards the south-west, and should be enclosed by a substantial wall, high to the north and to the east, but rather low towards the south and west: the former will preserve the plants from the chilling winds proceeding from those quarters, the latter will allow the genial breezes from the favourable points to circulate freely throughout the enclosure, while the sun will not be debarred during the cooler months, especially from visiting the interior in general. In the height of summer, as the sun rises and sets to the northward, the southern borders of the garden will be screened during the heat of the day, but will, during the early and late hours of its stay above the horizon, receive sufficient warmth without being scorched. Hence the south side, generally speaking, affords a shady border.

The soil of a garden should be deep, rich and clean: without such qualities the produce will be inferior, while the labour and expense will be enhanced in exact ratio with the defect. Nor can a garden be too abundantly supplied with water; the absence of which, in adequate proportion, will render every effort towards perfection totally unavailing.

It is of the utmost importance that the whole garden should have a free access of air, and that the subsoil should be wholesome and sound. The great exhaustion occasioned by constant cropping demands liberal supplies of rich manure, that the soil should be kept in excellent heart. Nor should such parts as are intended for the production of vegetables be crowded with trees, or bushes. We should advise in the strongest manner, that such trees, &c. as spread their roots widely, be interdicted altogether, and that such as may be considered as really indispensable be set out at ample distances, and not allowed to over-shadow the beds.

It is possible, however, to have the soil of a garden made too rich, that is, for the production of vegetables in general, many of which require an open free soil, not too highly dressed. Carrots, parsnips, and even turnips, may be injured by over-richness; while onions, mushrooms, asparagus, &c. delight in such parts as are manured even to a degree of rottenness.

The directions given under the head Gardening will furnish ample instruction on this subject; and will give, in a concise form, the leading features of the art, in such manner as may prove useful to, and be easily retained in memory by, those who may not be provided with publications treating abstractedly on that subject.

GARDENIA, in botany, so named in honour of Alexander Garden, M. D. of Charlestown, in Carolina, a genus of the Pentandria Monogynia class and order. Natural order of Contortæ. Rubiaceæ, Jussieu. Essential character: corolla one-petalled, contorted or twisted; stigma lobed; berry inferior, two to four celled, many-seeded. There are fifteen species.

GARDENING being a science of the utmost importance to the community at large, is followed by many persons with considerable advantage to themselves. Indeed, what is called market-gardening is a medium between private horticulture and that part of farming which relates to the production of green crops. We shall in this confine ourselves to horticulture, as suited to ornament, and to the management of grounds cultivated with the view to family supply. The following list of fruits is usually resorted to, when forming a garden. Apples in all their varieties, pears ditto, plumbs ditto, peaches ditto, apricots ditto, nectarines ditto, cherries ditto, figs ditto, grapes ditto, mulberries ditto, medlars, quinces, walnuts, chesnuts, filberds, gooseberries, currants, raspberries, strawberries. The vegetable department usually consists of the following: asparagus, artichokes, ditto Jerusalem, beans, peas, kidney-beans, running ditto, turnips, cauli-flowers, cabbages, brocoli, coleworts, sea kale, cucumbers, onions, leeks, radishes, lettuces, celery, endive, spinach, beets, parsley, fennel, cardoons, cress, mustard, chevril, potatoes, carrots, parsnips, melons, mushrooms, and love-apples: with capsicums, hyssop, marjoram, sage, mint, thyme, balm, lavender, rosemary, basil, clary, borage, and penny-royal, for pot-herbs, &c.

The flower tribe are as follows: First class, or tender annuals: amaranthus of sorts, stiamonium, egg-plant, balsams, ice-plant, sensitive plant, humble plant,

scarlet convolvolus, snake-mellon, and martynia.

Second class, or less tender annuals. African marigold, French ditto, aster of sorts, chrysanthemum, sweet sultan, Indian pink, palma-christi, tobacco, love-apple, gourds, persicaria, Indian corn, mignonette, convolvolus, capsicum, basil, lennia, stocks, tree-amaranthus, carmacorus, Chinese hollyhock.

The third class or hardy annuals. Adonis, larkspur, lupin, sunflower, lavatera, convolvolus major, starry-scabius, hawkweed, carthamus, nasturtium, Tangier-pea, honey-wort, nigella, catch fly, lychnis, navel-wort, Virginia stock, pansies, snail-plant, cyanus, xeranthemum, garden marigold, purple ragwort, dracocephalum, bastard fumitory, amythysten.

The hardy biennial and perennial flowers are these: Aster, Tripolian, dog's bane, arum, asclepius, astragalus, alysson, bachelor's button, borage, ragged-robin, campanula, Canterbury-bells, caltha, cassia, carnations, pinks, sweet-william, wall flowers, stock July flowers, French honey-suckle, tree primrose, lichnidea, cyanus, lichnis, rose campion, hepatica, linaria, bee lark-spur, fraxinella, gentiana, fox-glove, globularia, cyclamen, chelone, gold-locks, lilly of the valley, Solomon's seal, filapendula, columbines, ibalictrum, pulsatilla orebus, vesovian, golden rod, valerian, rudbekia, pulmonaria, monarda, jacea, ephemeron, primrose, polyanthus, auricula, violet, London pride, day-lilly, aconite, hellebore, geranium, daisies, ranunculus, peony, silphium, iris, cardinal, rocket, scabius, eringo, angelica, asphodel, ononis, lupins, eupetorium, balm of Gilead, moth-mullien, snap-dragon, and Tradescantia.

The bulbous and tuberous kinds are, amaryllis, crocus-vernus, snow-drop, ornithogalum, erithronium, muscaria, fritillaria, crown imperials, tulip, gladiolus, anemone, ranunculus, pancratium moly, fumaria-bulbosa, Narcissus, jonquil, lily-squill, asphodel, tuberose, iris, hyacinth, leontice, colchicum, cyclamen, corona-regalis, aconite, and sisyrinchium.

Plants suited to the hot-house are, Aloes, arums, ambrosia, anthyllis, aretotis, aster, (African) apocynum, apium, asparagus, (shrubby), bosea, campanula, buphthalmum, chysocoma, convolvolus, (silvery), celastrus, Cliffortia, caper, cistus, chamomile, (Italian), cyclamen, coronilla, crassula, cytisus, digitalis, diosura, iris-uvaria, euphorbia, geranium, guaphalium, grewia, heliotrophium, hyperium, Hermania, jasmine, ixia, justicia, leonurus, kiggellaria, lemon, orange, citron candy-tuft, dotus, lycium, lentiscus, lavatera, Malabar-nut, mesembryanthemum, myrtle, oleander, olive, opuntia, osteospermum, ononis, physica, phyfalis, sage, (African), silver-tree, scabius, sempervivum, sideroxylum, sedum, solanum, arvonum-Plini, pomum-amoris, stapelin, tetragonia, tucrium, tree-germander, and tanacetum-frutescens.

The trees and shrubs designed for the ornament of pleasure grounds, &c. are either evergreens, which retain their foliage, or deciduous, which shed their leaves usually on the approach of winter.

The list of evergreens comprises arbor vitæ, arbutus, cedar, cork, cypress, pine, fir, holly, magnolia, laurel, oak, yew, alaternus, cistus, coronilla, enonymus, juniper, hartwort, horse-tail, kalma, honey-suckle, laurustinus, bay, spurge, knee-holm, phillyrea, privet, purslane (tree), phlomis, rose (evergreen), rhododendron, savin, stone-crop (shrub), widow-wail, groundsel (of Virginia), germander, jasmine (Italian,) lotus, phyracantha, medicago, bignonia, tutsan, rag-wort (sea), wormwood, ivy, and furze.

The deciduous are, acacia, ash, cratægus, maple, hornbeam, medlar, chesnut, walnut, hiccory, birch, beech, sycamore, plane, larch, laburnum, liquid-amber, lac, lime, cypress, catipha, poplar, arbor-Judæ, alder, willow, elm, hamamelis, service, oak, tacamabacca, persamen plumb, aguus-casters, almond, althæa-frutex, Andromeda, Arabia, azelea, berberry, bladder-nut, broom, cephalanthus, bramble, viburnum, uoleosia, tupelo, empatrum, licium, chionanthus, laurustinus (African), xanthoxylium, melia, lavender, gale, spiræa, scorpionsena, smilax, syringa, sumach, toxicodendron, tamarisk, sassafras, pistachia, filberd, hazel, jesuit's bark, honey-suckle, frangula, jasmine, hydrangia, hypericum-frutex, lilac, silver-ivy, Robinia, Louisera, St. Peter's wort, mezereon, kidney-bean tree, tallow-tree, barba-jovis, mevispernum, oleaster, peach, privet (common), palmirus, privos, periploca, flamula-jovis, itea, ptelen, cherry, rhamus, raspberry, myrtle, coccigria, cinquefoil-shrub, colutea, clathea, bush-cassiberry, bignonia, Benjamin, euonymus, dogwood, Guelder-rose, thorns (black and white), azerole, Naples medlar, mespilus, celtis, pear, bastaria, bird-cherry, tulip-tree, rose, briar, pomegranate, currant, gooseberry.

Those plants which are reared in green or hot-houses, and are raised from seed, as well as a great variety of tender annuals, are generally produced from hot-beds,

made by collecting fresh stable-dung, or tanner's bark, while capable of affording a great degree of heat. Over these beds, which are sometimes framed in with wood-work for masonry, fine soil is laid to the depth of four, five, or six inches, or in some cases more, and glass frames are fitted as covers, in such manner as to open to any desired extent. When the first heat has subsided, and the temperature is such as not to scorch, the seeds of melons, cucumbers, &c. may be sown, or the pots, containing curious plants, may be partly buried, so as to obtain a greater degree of heat than is afforded by the air without the frame. In this manner, the most tender exotics may be propagated; indeed many become gradually so inured to our climate, as to be perfectly habituated; and after fifteen or twenty generations (or seasons, if not very perishable) may in some instances be treated the same as our tender indigenous plants. Such, however, as are not disposed so to assimilate, must be preserved in green-houses, or eventually be kept in hot-houses during the cold months; being there confined in an artificial atmosphere, highly rarefied by means of a fire, which warms a variety of flues that every where intersect the walls of the building. See Hot-house.

Having said thus much, in general terms, regarding the trees, shrubs, and vegetables, ordinarily appropriated to gardens and pleasure-grounds, we shall give the reader a brief code of instruction as to the seasons and modes appropriate to each individually, arranging the whole in form of a calendar.

JANUARY.

Kitchen-garden. Make up your hot-beds for melons, cucumbers, &c.; for early produce, select the romana and cantaloupe melons, and the early prickly cucumber. The plants will rise in a week, but you should never keep them so hot as to steam the glasses. Sow successively, in case of accidents, to which this class are very subject. If the beds cool too much, lay fresh litter all around them; or, if practicable, rake out some of the old litter, and fill up with very fresh dung; avoiding much pressure. The outside dressing will require to be changed every fortnight, as the heat will in that time be greatly abated. When the plants have made two good shoots, exclusive of their first leaves, you may remove the pots, in which they were sown, to a larger bed, where they are to remain, stripping off such shoots just beyond their second joints. In such beds you may force asparagus, lettuce, small-salading, love apples, radishes and an infinite variety of vegetables for early use: this will, however, require extensive and numerous beds.

You may in this month, if the weather be mild, sow parsley, beans, and peas, spinach, carrots, &c. but do not depend on their succeeding: they should all be sown on warm borders. Plant out cabbages, for summer use, and in all the varieties for seed. For this latter purpose, you may keel in any old stems that have good sprouts on them, they will furnish excellent seed, plant them in an open part, in a deep, well-worked soil, highly manured; your cauliflower plants, that stand under glasses, should be clean picked from all decayed leaves, and be well weeded; give them air occasionally during mid-day, when the sun is out; but close up well at night, so as to shut out the frost; if intensely cold, cover with matting, straw, &c. earth your celery up well in dry, open weather, breaking the earth very small, and applying it gently; remove all the rotten tops, by twisting them off very carefully; your endive should also be picked, and tied up, in fair weather. If the plants appear wet, and injured in the heart, take them up, and, after hanging for two or three days, by their roots, to drain, transplant them into clean, well prepared-beds, earthing them up half way of their leaves, but taking care that no soil be admitted within them. Artichokes should be attended to, and well landed up; also be supplied with long litter, to preserve them from frost; cover your mushroom-beds well for the same reason.

In the Fruit-garden, finish the pruning of your apple and pear-trees, training all the shoots that are to remain, at full six inches asunder; you must also prune and nail your plum and cherry trees, as well as your peaches, apricots, and nectarines, provided the weather is mild, else it were better deferred to a more favourable time; however, you need not be apprehensive from slight frosts. Always loosen the whole tree before you begin to prune, so that you may remedy any defects, and be enabled to make a more perfect arrangement, cutting out all useless wood. You may prune vines when the weather permits, keeping only the shoots of the last season, no others being bearers. Gooseberries and currants must be trimmed with a bold hand, to allow free access of sun and air; keep only the wood of one or two years. Raspberries must be looked

to, cutting away all but the young shoots; these should be shortened about one-third of their length. You may now set out the cuttings from gooseberries and currants, and the young shoots of raspberries; plant at least four feet asunder every way, else your fruit will be small, and deficient in flavour: choose an open situation and a free soil.

You must now prepare ground for plantations of fruit-trees, choosing good situations; your wall and espalier trees ought to have ample room, not less than twenty feet asunder: in a few years they will cover well, and bear rich crops; standards ought to be full forty feet apart: if the weather proves severe, defer this work until it mode rates, and look well to your old trees, covering their roots with litter, and supporting newly-planted standards with stakes, leaning on hay-bands, so as not to injure the bark. Prune old standards, and begin the forcing of hot-house plants by closing well up, and keeping a temperature of from seventy-five to eighty degrees, Fahrenheit. As the fruit begins to ripen, allow water in moderation. Your strawberries will particularly come under notice in the forcing time; and all the potted plants must be placed in hot-beds for that purpose.

In your Flower-garden, see that the auriculas, carnations, hyacinths, and tulips, be well sheltered from inclement weather. You may now plant tulips, anemones, ranunculuses, crocuses, jonquils, narcissuses, hyacinths, and all other bulbs; or you may set the roots on mantle and chimney-pieces, on glasses filled with water. Let all your perennial fibrous-rooted plants, such as double wall-flowers, double stocks, double sweet-williams, chrysanthemums, &c. &c. that are in pots, or under frames, be carefully attended to. Cover seedlings and tender plants, not omitting to give air in mild weather. You should now prune and dig between your flowering shrubs; and may plant out roses, honeysuckles, lilacs, laburnums, privets, jasmines, and a great variety of the hardy class, observing to arrange them tastefully, according to their colours, foliage, &c. and setting those which are tallest, when full grown, in the back part, whereby you will not obscure the lesser kinds. All hardy shrubs may now be propagated by layers; and suckers may be removed from roses, syringas, aspiræas, lilacs, &c. into rows, where they should stand for about two years, and then be set out to where they are to remain; cuttings of hardy deciduous shrubs will now proceed. Trim your grass-walks and lawns, throwing down worm-casts, and rolling with a wooden roller. You may at this season pare and lay turf. In dry weather, lay down and roll the gravel-walks that were ridged; plant thrift and box edgings, if not done in October or Novermber. Forest and ornamental trees should now be planted on dry soils; these should, properly, be of the hardy kinds. Hedges may be planted or plashed.

In the Nursery. Transplant and prune your forest-trees, particularly those that are deciduous, if the weather admits; for ever-greens the weather must be settled; prune and transplant flowering shrubs; plant fruit-tree stocks, and prepare for extensive plantings and sowings; in frosty weather carry dung, &c. losing no time; take great care of young and seedling trees; propagate by cuttings

In the Hot-house. Your pines will require great care; you may also raise kidney beans, cucumbers, strawberries, &c. and have abundance of flowering plants therein.

FEBRUARY.

Kitchen-garden. Cucumbers and melons will be sown with better success in this, than in the former month; but take care they have not too much heat, as they will be apt to wither: to prevent this, let them be sown or set upon little hillocks, or ridges, which will expose a greater surface to the air; stop, *i. e.* pinch off, the young plants at the first joints of the first shoots, so as to cause their sending out many fruitful runners; do this when they have two rough leaves, not longer than a shilling; force asparagus in hot-beds, breaking off the shoots with your finger, avoiding to cut them; kidney-beans, small salading, &c. may proceed, as shewn in the last month's directions; give your cauliflower plants air, and by the end of the month you may plant out to two feet asunder, taking care to cover with haulm, &c.; if the weather comes on very cold, leave one plant under each glass; sow cauliflower seed, transplant cabbages, sow cabbage and savoy seeds, also early celery, radishes of sorts, spinach, lettuces, carrots, parsnips, beets, leeks, onions, beans, peas, pot-herbs, potatoes, horse-radish, turnips, liquorice, &c. for a general crop; taking care to break the soil well, and to choose favourable times for putting in the seeds, or sets.

In the Fruit-garden. Continue to prune fruit-trees, and especially vines, dress

strawberry beds, plant fruit-trees, dig the borders, graft, and go on forcing the early flowers and fruits.

In the Flower-garden. You may sow tender annuals on hot-beds, during the early part of the month; and towards the end all the hardy annuals; plant out the hardy fibrous rooted plants, such as primroses, violets, polyanthuses, &c.; dress your auriculas, and sow their seed; also those of the polyanthus, in rich, light earth, very shallow; transplant your carnations, defend bulbous roots, prune flowering shrubs, plant out such as are wanted, together with evergreens; plant hedges, lay turf, trim lawns and walks, set box, &c. for edgings.

In the Nursery. Propagate by cuttings, suckers, and layers; transplant layers, flowering shrubs, stocks to graft on, fruit and forest trees; sow seeds of ditto, and head down budded stocks.

In the Green-house. Look to the shrubs, &c.; giving air, and water, in proportion to the mildness of the weather. You may now trim myrtles, oranges, &c. to any intended form.

In the Hot-house. The pines will demand much assiduity; for an improper degree of heat will at this period injure them very considerably: keep up to 75 degrees, by means of fresh bark to be mixed with that in which the pots were plunged. Moderate watering will contribute both to growth and flavour. Keep your exotics very clean from decayed leaves, and wash dust, &c. from the leaves; above all things, remove cob-webs wherever they appear; and, if necessary, fumigate, to destroy insects, which will now begin to shew themselves. Fresh air must now and then be admitted, when the weather admits. Your strawberries, kidney-beans, cucumbers, roses, &c. will now get fast forward; but you must guard against frost, which would do great injury, if your fires were neglected.

MARCH.

Kitchen-garden. Attend to your cucumbers and melons; you may now sow the seeds of the later sorts; such as the Smyrna, the long green, and long white Turkey kinds. Make new hot-beds, to receive them when fit to transplant. About this time, your cauliflower-plants may be removed from the warm borders, and set out; these will now occupy the beds of your spinach and radishes; which will soon be gone, and leave only the cauliflowers. Sow brocoli for an autumnal crop; also cabbages, some of which may now be transplanted. Sow savoys, and lettuces, also spinach, leeks, onions, borecole, radishes of sorts, carrots, and parsnips, all on good soil, well prepared, and made very fine; fork and dress up your asparagus, and plant out where wanted; you may also sow some seed; dress your artichokes, and plant out; set beans for a full crop, also peas; earth up any that are grown sufficiently; sow turnips for a full crop, also celery, small salad, and all the tribe of medical and pot-herbs; nasturtiums may be sown very early in this month; capsicums should be in a hot-bed, and be set out as the weather grows warm, after they have four leaves; if six, or eight, the better. Love-apples will require the same treatment; kidney-beans, potatoes, and Jerusalem artichokes, should not be omitted. Set slips of rosemary, rue, chives, mint; and let your garlic, scallions, cardoons, &c. now be committed to the soil.

In the Fruit-garden. Prune your fig-trees, and plant also where they are wanted; if your wall fruit-trees have not been trimmed, lose no time in attending to them; some will be in bloom, if the season favours; cover such with mats at night, to keep the frost from injuring them. Fruit-trees in general may yet be planted out, but no time should be lost; and the borders in which they stand should now be well dug. Prune vines, and propagate by means of cuttings. It is expedient to remark, in this place, that it has been recently proposed to graft vines upon elders at this season, under the idea of producing early fruit, and of giving the clusters more time for ripening; the suggestion is assuredly ingenious, and merits trial. Dress your strawberries well, and run light whisps of straw at right angles under the foliage, so as to support the leaves, and to retain the moisture in the soil. Continue to force your early fruit, taking care to keep up fires every night.

In the Flower-garden. You will find ample employment in setting out your early annuals, sowing tender annuals on hot-beds, and the more hardy sorts in warm borders. Fresh earth must be given to plants in pots; the chrysanthemums, auriculas, carnations, hyacinths, &c. will now demand care, as will all your curious flowers. Now plant anemones, and ranunculuses, and sow the fibrous-rooted annuals and biennials; transplant perennials, prune your shrubs, hoe and rake your borders, dig where necessary, and clean your clumps; plant deciduous flowering shrubs, and forest-trees; transplant your evergreens, remove roses, plant edgings

and hedges, clean your garden wall, clear your gravel walks from rubbish, lay your turf where wanted, and roll your lawns very smooth in dry weather.

In the Nursery. Graft on proper stocks, sow the seeds of deciduous trees and shrubs, propagate also by cuttings, sow hardy ever greens; weed the whole carefully, and water seedlings.

In the Green-House. Moderate the heat, by admitting fresh air in mild weather; if frosty, or very cold, keep all shut close; trim your orange-trees, myrtles, &c. into shape; shift such plants as require larger pots, give fresh earth to the roots in general; sow the seeds of exotics, and of oranges for stocks.

In the Hot-House. Your pines will begin to shew fruit; therefore keep up the heat, water these plants frequently, and, in favourable days, admit a little air.

APRIL.

Kitchen-garden. Keep up your hot-beds for cucumbers and melons, allowing the young plants air daily; give water occasionally, and remove decayed leaves; if the sun is very powerful, put mats, &c. over your glasses; impregnate the female flowers, by means of the fine powder on the antheræ of the male blossoms, this will insure an early crop, and should be done on the day the flowers first open; make hot-bed ridges, to receive the plants intended to be set out under bell or hand glasses; sow melon and cucumber seeds for a late crop, plant out your lettuces, sow small salading, radishes, turnips, spinach, kidney-beans, brocoli, onions, leeks, cardoons, carrots, parsnips, pot-herbs, capsicums, love-apples, scorzonera, salsafy, purslane, beans, peas, gourds, and pompions; set potatoes for a late crop, and plant slips of pot and sweet herbs; destroy weeds, and water young plants when the weather is dry.

In the Fruit-garden. You may plant trees, propagate vines, summer-dress the old ones, protect the blossoms of wall-fruit, rub off useless buds, and thin the fruit where too numerous; you may yet prune, and graft, or bud; destroy insects and weeds, clean your strawberries very carefully, and clear them from runners, except what you keep for planting out in June; water these plants well, or they will bear but poorly.

In the Pleasure-garden. You may yet sow tender annuals on hot-beds; the more hardy will succeed with less heat, and the hardy will only require warm clean borders: your bulbous roots will be in blossom, and must be amply watered; in very hot weather you must shade them, or they will soon pass off; carnations and polyanthuses may yet be sown; those in pots will demand attention; transplant fibrous rooted perennials, sow some also; set your tuberoses in hot-beds, or in hot-houses; pay attention to your auriculas, and save their seed very carefully; sow balm of Gilead, plant out ever greens and flowering shrubs, propagate them; roll your grass walks often, and, if too luxuriant, mow them; plant box and thrift edgings, put sticks to your flowering plants, roll your gravel-walks after turning them, and destroy weeds every where.

In the Nursery. Finish sowing ever-greens, flowering-shrubs, and tree-seeds; water your seed-beds, transplant ever-greens, examine your grafts, and make new ones early in the month.

In the Green-house. Give air to your plants, water and shift into larger pots or tubs, put fresh earth, cleanse the plants, head down myrtles, &c. inarch, and propagate by seeds and cuttings.

In the Hot-house. Your pine-apples will demand daily attendance, and must be liberally supplied with water, keep the heat well up, admit air occasionally in suitable weather; stove exotics may now be propagated by seeds, cuttings, layers, or suckers.

MAY.

Kitchen-garden. As your melons and cucumbers, will be getting fast forward, you must carefully keep up the heat of your beds by fresh linings of dung, and screen from cold at night; in the day, give air at suitable times, and occasionally water moderately. You will now, in all probability, have occasion to raise your glasses, so as to give room; do this by putting bricks, &c. under the frames. As the melons set, place a tile under each, else the damp of the bed will stain and render the lower part unsightly. You can now sow cucumbers for pickling: this may be done in a free soil, fully exposed to the sun. At night cover the young plants with straw, &c. You may also sow gourds, &c. This is a good time for a full crop of kidney beans, and, if fair, for the scarlet runners: put in small salading, spinach, turnips, carrots, parsnips, onions, for succeeding crops; taking care to weed and water those formerly sown: set out cabbages and savoys; screen your cauliflowers from the sun, by

bending in the leaves over the flowers, which will now be forming: water these plants well, making a trench, or basin, for that purpose: transplant cauliflowers, and sow for a Michaelmas crop. Sow brocoli, borecole, beans, peas, &c. and stick the peas which are ready; top off your blossoming beans; sow endive, for an early crop, propagate pot-herbs and aromatics by cuttings, &c. Support seedling plants, prick out celery, and sow some, also some radishes; thin your cardoons, and weed with diligence: if the weather proves dry, water liberally.

In the Fruit-garden. Look to your wall trees, protect from birds and insects, which by the end of the month will be pecking at your early fruits; trim the shoots and leaves of all fruit-trees, to allow the fruit sun and air, but without scorching; thin your wall-fruit where too close or abundant; destroy snails, keep your borders clean, fumigate, to kill small insects, water new planted trees; clear away superfluous clusters from your vines, look to your strawberries, watering them amply; examine grafted trees.

In the Flower-garden. Be attentive to your bulbous flowers, take up such as have lost their leaves, and lay them to season; your carnations will require care, trim off all puny flowers; your tender annuals must be again removed to a fresh hot-bed; those sown last month may now be pricked out: the less tender may be set out into open spaces, if the weather is warm, choosing moist weather for that operation. You may sow hardy annuals, and propagate double flowers by slips: preserve seedling bulbs from too great heat. When your auriculas have done flowering, remove them to the open air; plant tuberoses for the next year, transplant perennial flowers, and sow some of their seeds; destroy weeds, mow your lawns, and keep your gravel walks perfectly clean.

In the Nursery. Water seedlings, and shade them, if hot weather; propagate evergreens by layers, and look over your grafts.

In the Green-house. A free circulation should be allowed, and the plants be gradually introduced to the open air; remove decayed parts, and shift into larger vessels where wanted; water freely, and propagate by layers and cuttings.

In the Hot-house. Your pines will want water often, and fresh air occasionally; ou must look to your exotics, and propagate by seeds, cuttings, suckers, &c.

JUNE.

Kitchen-garden. Your melons must be protected from excessive heat by mats over the glasses, which they will now bear to be well raised, water them and your cucumbers; all under bell-glasses should have free range; thin out the gerkin plants, leaving four in each hole, setting out the rest as before directed into ridges, &c. You may yet sow for pickling; transplant celery into trenches for blanching, also endive; set out lettuces, and sow more seed; sow radishes, and small salading; prick out cauliflowers, and pay attention to those now getting forward, save some seed from the best heads; sow a full crop of turnips for autumn; weed and loosen about your carrots and parsnips, also your beets; thin and clear your onions; transplant leeks, brocoli, and borecole; plant kidney and running beans; sow peas and beans for late crops, and a full crop of cabbages and savoys for winter. Cut no asparagus after this month; plant pot-herbs, gather mint, plant out capsicum, love-apples, and basil; water freely every where; weed carefully, set out cardoons for blanching; sow spinach and radishes; and keep your manure compact, so as not to be injured by the heat.

In the Fruit-garden. Keep your wall-fruit clean from insects, and guard against birds; thin the sets where too numerous. Where apple, pear, plum, &c. trees have made shoots, regulate them duly, taking off all that would be superfluous close to the stems; new planted trees should be examined, and eventually watered. Look over your vines again; towards the end of the month you may bud, or inoculate some fruit trees. Clear your strawberry beds from suckers, and set out where you want new beds, or to supply vacancies. Destroy snails, and scare birds.

In the Flower-garden. Transplant hardy annuals, water tender annuals; some quick flowers may yet be sown, to blow in autumn; take up the bulbs that are past flowering, transplant Guernsey and Belladonia lily roots, propagate fibrous rooted plants, transplant seedlings, look to your carnations and pinks, both old and seedlings, lay them, as also double flowers of various kinds, propagate by pip-

ings (or cuttings,) cut edgings, clear away weeds, water freely, mow lawns and vallies, and clip hedges.

In the Nursery. You may inoculate stove-fruit trees, examine last years' buds, graft in general; inoculate roses; propagate hardy exotics, water seedlings, and shade them; water trees newly planted, and transplant seedling pines, firs, &c.

In the Green-house. Admit air to the fullest extent, and bring the plants out into the open air; water and stir the soil in the pots, wash off dust, destroy insects, cleanse the interior well, plant cuttings and slips of myrtle, geranium, &c. Propagate succulent plants, letting the cuttings remain in a dry airy place about ten days. You may inarch upon orange and lemon trees, make layers of green-house shrubs, and transplant seedling exotics.

In the Hot-house. Give fresh air and abundance of water, but not too much at a time: take off the crown and side swellers from the ripe fruit, as they will in two years bear fruit.

JULY.

Kitchen-garden. Plant out the principal crops of cabbages, &c. watering them well for several days; plant out brocoli, and sow seed for spring crops; transplant endive, and sow seed for winter crops; you may yet sow kidney and scarlet beans; set out the cauliflowers sown in May; sow small salading and winter onions, also carrots for autumn; transplant celery, and land up that formerly set out; sow turnips; plant out lettuce, sow some seed also of winter spinach, radishes, and cole-worts; pull onions, garlic, and shallots; be prudent in not giving much water to your ripening melons, as it would hurt their flavour; for the same reason shelter them from heavy rain. When you have cut artichokes, break the stem down close to the root. Set out cardoons, gather seeds, transplant leeks, collect herbs for distilling while early in flower; plant sage, &c. gather physical and pot-herbs for drying; sow peas and beans for a late crop; water freely and clear your ground.

In the Fruit-garden. Look to your wall trees nail up your fig-trees, look again to your vines in particular, destroy wasps and insects, not forgetting snails. Bud your stone-fruit trees, and preserve seeds.

In the Flower-garden. Bring out your curious annuals that were as yet in frames, &c. clear them well, and wash well with a light pot pierced very small; transplant annuals into the borders, &c. select carnations, which must be carefully preserved, lay them, as also double sweet-williams, &c. transplant former layers, propagate pinks by pipings; set out perennial plants, clean your auriculas, transplant their seedlings; take up remaining bulbs, propagate the double scarlet lychnis, &c. by cuttings; mow lawns and walks, cut edgings, and clip hedges, destroy weeds, and cut away decayed flower-stems.

In the Nursery. Bud your stone-fruit trees; grafted trees are to be examined; transplant seedling firs; inoculate and lay curious shrubs; water freely, and destroy weeds.

In the Green-house. Water your bearing trees in particular; give them new soil; propagate exotics by cuttings, &c. plant cuttings of succulents; bud your oranges and lemons.

In the Hot-house. Admit air in calm clear weather; propagate pines as before shewn; water moderately, and pay attention to your exotics.

AUGUST.

Kitchen-garden. Sow a full crop of winter spinach, also cabbages, brocoli, savoys, winter onions, carrots for spring use, radishes, some cauliflowers for next summer; transplant celery, and earth up former trenchings; sow small salading, lettuce, fennels, angelica, carduus, endive, cole-worts, &c.: clean your beds of asparagus; earth up cardoons; look to your onions, garlic, and shallots; propagate sweet herbs; gather seeds; and see to your melons and cucumbers, which will now be in bearing. You may likewise sow turnips for a late crop; hoe your former crops well in dry weather.

In the Fruit-garden. Keep your wall fruit very clean, and guard against birds and vermin; let your figs have a due exposure to the sun; look to your budded trees: you may still bud early in this month.

In the Flower-garden. Propagate fibrous-rooted plants; water generally; propagate saxifrage in particular; sow auricula seeds, and shift those plants into fresh earth, pick out their seedlings; remove carnation layers and pink pipings; lay carnations; sow seeds of bulbs, also of the anemone, cyclamen, and ranunculus; remove late flowering bulbs; transplant perennials; clip hedges; cut edgings

mow lawns; trim flower plants, and gather their seeds; plant autumnal bulbs; and destroy weeds very carefully.

In the Nursery. Water freely; transplant seedlings; trim evergreens; bud in the early days; and prepare ground for transplanting.

In the Green-House. Shift succulent plants into larger vessels; propagate aloes by offsets from the old plants; inoculate orange trees; and water so as to keep the soil from caking.

In the Hot-House. Water freely every other day; shift the succession of pine-apples into larger pots, in which they are to bear; give but little water to ripening pines, lest the flavour be weakened.

SEPTEMBER.

Kitchen-garden. Now prepare your beds for mushrooms, making them of the best fresh stable dung, in which the best spawn should be set; if heavy rain should fall before completed, cover with long dry litter; take care only to cover the spawn about half an inch. Keep these beds very dry in winter; in very hot weather sprinkle occasionally with water. A mushroom bed will produce in five or six weeks; and old cucumber beds will often produce immense numbers. Plant and sow lettuces; put some also into frames for winter service. Set out your young cauliflowers into a nursery bed, to stand the winter. Earth up the Michaelmas cauliflowers, and urge them to perfection, watering them abundantly, else they will be stunted. Transplant your young brocoli. Plant out your late savoys and cabbages, also your celery and coleworts. Earth up your ridged celery. Tye up endive to blanch, and plant out more for a succession. Begin to blanch the more forward cardoons. Weed your young spinach and winter onions. Hoe your turnips in dry weather with a bold hand. Continue to sow small salading, chervil, &c.; and gather your ripe seeds in fair weather.

In the Fruit-garden. Thin the leaves from over your ripening wall-fruit, especially your grapes; hang up phials of syrup every where, to decoy wasps and flies; gather your apples and pears; prepare for plantations of fruit trees, and set out strawberries at good distances.

In the Flower-garden. Plant your hyacynth and tulip roots for early bloom; prepare beds for your ranunculuses and anemones, sorting the seeds late in the month; look to your carnation layers, and to your auriculas that are in pots; sow auricula seed, if not done before; transplant perennials; sow seeds of bulbs; plant box; dig borders; roll gravel walks; trim flowering plants; propagate fibrous-rooted plants; transplant pionies, and other knot-rooted plants; as also flowering shrubs in general.

In the Nursery. Transplant evergreens, deciduous shrubs and trees; prepare ground for receiving your late grafts, and for new stocks; propagate trees and shrubs by cuttings; preserve cherry and plum stones to raise stocks; and destroy weeds and nests of vermin.

In the Green-house. Prepare for the return of your oranges, &c. which, as the weather becomes colder, must be taken in, and gradually be more confined in regard to the atmosphere.

In the Hot-house. Admit air only when the sun is bright, and the wind from a warm quarter; water your pine plants moderately; add fresh tan to your pits; and prepare composts for this branch.

OCTOBER.

Kitchen-garden. Plant beans for an early crop, preferring mazagans; you may also sow some hotspur peas for the same purpose; transplant lettuces for winter service, and sow some for spring use; cover your cauliflower plants; set out your cabbages; force your brocoli, by loosening the soil, and drawing it around their stems; clean your winter spinach, tie up endive, and dress your bed of aromatics; plant and set slips of herbs; dress asparagus beds; earth up celery and cardoons; sow small salading and radishes, also carrots for spring use; dig up carrots, parsnips, and potatoes: begin trenching, for the benefit of winter exposure.

In the Fruit-garden. Gather your late pears and apples; prune and nail your wall-trees, also your standards, when the leaf has fallen; plant goosberries and currants, also prune them, and set the cuttings; dress strawberry beds, plant the runners; prune raspberries, and plant the young shoots; propagate fruit trees by layers and by suckers.

In the Flower-garden. Put your auricular plants in safe places, laying them on their sides to throw off the wet; set out your carnation layers; dress your flowering shrubs; transplant fibrous-rooted flowering plants, parting the roots of such

as will admit; plant all kinds of bulb; prune flowering shrubs; plant hardy deciduous flowers and shrubs and evergreens to hide walls; firs and pines should now be transplanted, as also forest trees in general; propagate them by layers; transplant such layers as may be ready; propagate roses, &c. by suckers, and others by cuttings; set your seedlings in a warm place; trim your evergreens; plant box; and cut hedges and edgings

In the Nursery. Propagate by layers, and transplant such as may be ready; proceed also with cuttings; sow haw and holly berries; sow acorns; set out seedling stocks for grafting; sow plum and cherry stones; transplant laurels; sow beech, and various seeds of hardy trees.

In the Green-house. See that your shutters fit well, and have all your benches, &c. well cleansed and repaired; move in your plants in due time, if not done before; water occasionally, but in small quantity.

In the Hot-house. See that your tanpits are in proper state, and set your pots in carefully.

NOVEMBER.

Kitchen Garden. Sow beans, peas, radishes, small salading, &c.; look to your celery and endive, so that they may blanch well; attend also to your cardoons; cut down your artichokes; give air to your cauliflower plants; clean your spinach; manure and trench; you may sow a little carrot seed, but it will prove a precarious crop; weed your spring onions carefully.

In the Fruit-garden. Prune and nail vines, apricots, &c.; plant wall-trees, apples, pears, cherries, &c.; clear your fig-trees of the remaining fruit, and if severe frosts come on, cover them with mats; plant filberts, and in general all deciduous fruit trees and shrubs.

In the Flower-garden. Clean your borders, plant perennials, tulips, ranunculuses, anemones, crocuses, narcissuses, and other bulbs; prune flowering shrubs; transplant hardy shrubs; plant forest trees; roll grass walks and lawns, and keep your gravel clean; prepare good compost for your flowers.

In the Nursery. Finish all transplanting; prepare for new plantations; manure well; and shelter seedlings from wet and from frost.

In the Green-house. Some few plants will want watering, and it will be proper to keep the night air entirely out.

In the Hot-house. Make a moderate fire at night; on sunny days you must open a sash or two, and should occasionally bestow a little water where wanted.

DECEMBER.

Kitchen-Garden. Examine your cauliflower plants; you may sow beans, peas, &c. if the weather is open; keep your mushroom beds dry; make a forcing bed for early asparagus; trench and open the vacant soil, giving a good allowance of manure where wanted.

In the Fruit-Garden. See that your wall-trees are firm, and cover places that seem likely to canker, cutting away all useless wood, but preserving sufficient bearing wood; prune fruit trees in general, and plant out if the weather admits.

In the Flower-garden. Preserve all tender plants and seedlings very carefully; transplant and plant as wanted.

In the Nursery. Look to your new plantations; trench, dig, and manure liberally; propagate by layers and suckers of hardy trees and shrubs.

In the Green-house. Keep your plants clean, and water occasionally.

In the Hot-house. Water as wanted; keep up a due temperature: you may commence for early cucumbers, kidney-beans, roses, pinks, &c.

GARDEN *snail.* See Helix.

GARIDELLA, in botany, so called in honour of Pierre Garidel, M. D. a genus of the Decandria Trigynia class and order. Natural order of Multisiliquæ. Ranunculaceæ, Jussieu. Essential character: calyx five-leaved, like petals; nectary five, two-lipped, bifid; capsules three, connected, containing many seeds. There is but one species, *viz* G. nigellastrum, fennel-leaved garidella.

GARLAND, in naval affairs, a sorts of net extended by a wooden hoop, of sufficient size to admit a bowl or platter, and is used by sailors as a locker or cupboard, to contain their provisions, being hung up to the beams within the birth, where they commonly mess between the decks.

GARLIC, in botany, see ALLIUM. This root has been subjected to chemical analysis; when distilled, it yields first a liquid slightly coloured, and having an acrid taste; then a thick brown oil, and abundance of inflammable air and carbonic acid. The liquid in the receiver emits the smell of ammonia when mixed with lime. It is said to consist of

Albumen,	Fibrous matter,
Mucilage,	Water.

GARNET, in mineralogy, is a species of the flint genus, of which there are two sub-species, *viz.* the precious, and common garnet. The precious, or Oriental, garnet is red, but of various shades; it occurs seldom massive, more often disseminated, and in original roundish grains and small pieces. It occurs most commonly crystallized, either as a dodecaedron, or as a double eight-sided pyramid. Its specific gravity is about 4.3, and it consists of

Silica	35.75
Alumina	27,25
Oxide of Iron	36.0
Manganese	0.25
	99.25
Loss	0.75
	100

Before the blow-pipe it melts into a black enamel.

The common garnet is brown or green, is not so heavy as the precious, and is composed of

Silica	26.46
Alumina	22.70
Lime	17.91
Iron	16.25
	83.32
Loss	16.68
	100

It is more easily melted than the precious garnet.

"The garnet varies more than any other gem, both in the form of its crystals, and in its colour; some being of a deep red, some yellowish, or of a purple tint, and others brown, blackish, and quite opaque. They are generally of a spherical form, and never crystallize with less than twelve sides. The prevailing colour is a fine red, and the mean size that of a large pea, though they are found from the size of a grain of sand to three or four inches in diameter. Those imbedded in granite are in general of the smallest size, but at the same time the most transparent. Among the garnets which are called Oriental may be distinguished three different shades, known in commerce by as many different names. The garnet of a fine red colour, and free from any mixture, is called a carbuncle. Garnets are found in almost every country where primitive rocks exist. Switzerland and Bohemia are the two countries in Europe which furnish them in the greatest abundance. Those of Bohemia have a tint of orange mixed with the red, from whence some have given them the name of rubies. These stones are likewise fouud in Hungary, at Pyrna in Silesia, in Spain, and in Norway. At Bareith, a town in Germany, garnets are found in little irregular masses of a fine red colour, and abundantly disseminated in a green semi-transparent stone called serpentine. As they are susceptible of a fine polish, the inhabitants form them into several pretty trinkets and other articles of jewelry. Black garnets are met with in different situations. Ramond, professor of natural history at Tarbes, collected some from a mountain of the Pyrenees in the neighbourhood of Barege; Rome de l'Isle found them in the diamond mines of Brazil; and Brongniart tells us that they have been discovered in a volcanic rock near Vesuvius, and in the basaltes of Bohemia. When garnets are perfectly transparent, and hard enough to bear a fine polish, the lapidaries cut them into facits, to be employed as jewels. In Bohemia there are places where they work the garnets which are found in the neighbourhood. There are workshops also at Friburg, in Brisgaw, for the garnets which are collected from several of the Swiss mountains. The impure garnets are used to advantage as a flux, when they are found near iron-mines, as they not only facilitate the fusion of that metal, but add something to the mass, by contributing the portion of iron which generally enters into their composition. The quantity indeed is sometimes so great, that they have been said to yield 40*lb.* in the *cwt.* and consequently worth smelting alone for the sake of their produce." See Wood's "Zoography," to which we have been indebted in the articles COAL and FICUS.

GARNET, in a ship, is a tackle having a pendant coming down from the mainmast, with a block well seized to the main stay, just over the hatch-way, to which a guy is fixed to keep it steady; and at the other end is a long tackle-

block, in which the fall is reeved, that so by it any goods may be hauled and hoisted into or out of the ship.

GARNISHEE, the party in whose hands money is attached, within the liberties of the city of London, so used in the Sheriff of London's court, because he has had garnishment, or warning, not to pay the money, but to appear and answer to the plaintiff creditor's suit.

GARNISHMENT, a warning given to one for his appearance for the better furnishing of the cause and court.

GARRISON, in the art of war, a body of forces, disposed in a fortress, to defend it against the enemy, or to keep the inhabitants in subjection; or even to be subsisted during the winter-season: hence, garrison and winter-quarters are sometimes used, indifferently, for the same thing; and sometimes they denote different things. In the latter case, a garrison is a place wherein forces are maintained to secure it, and where they keep regular guard, as a frontier town, a citadel, castle, tower, &c. The garrison should always be stronger than the towns-men.

GARTER, *order of the*, a military order of knighthood, the most noble and ancient of any lay order in the world, instituted by King Edward III. This order consists of twenty-six knights-Companions, generally princes and peers, whereof the King of England is the sovereign, or chief. They are a college or corporation, having a great and little seal.

Their officers are, a Prelate, Chancellor, register, king at arms, and usher of the black rod. They have also a dean, with twelve canons, and petty canons, vergers, and twenty-six pensioners, or poor knights. The Prelate is the head. This office is vested in the Bishop of Winchester, and has ever been so. Next to the Prelate is the Chancellor, which office is vested in the Bishop of Salisbury, who keeps the seals, &c. The next is the register, who by his oath is to enter upon the registry, the scrutinies, elections, penalties, and other acts of the order, with all fidelity. The fourth officer is garter, and king at arms, being two distinct offices united in one person. Garter carries the rod and sceptre at the feast of St. George, the protector of this order, when the Sovereign is present. He notifies the elections of new knights, attends the solemnity of their installations, carries the garter to the foreign princes, &c. He is the principal officer within the college of arms, and chief of the heralds.

All these officers, except the prelate, have fees and pensions. The college of the order is seated in the castle of Windsor, with the chapel of St. George, and the chapter-house erected by the founder for that purpose. The habit and ensigns of the order are, a garter, mantle, cap, George, and collar. The four first were assigned the knights companions by the founder; and the George and collar by Henry VIII. The garter challenges pre-eminence over all the other parts of the dress, by reason that from it the noble order is denominated; that it is the first part of the habit presented to foreign princes, and absent knights, who, and all other knights elect, are therewith first adorned; and it is of so great honour and grandeur, that, by the bare investiture with this noble ensign, the knights are esteemed companions of the greatest military order in the world. It is worn on the left leg between the knee and calf, and is enamelled with this motto, HONI SOIT QUI MAL Y PENSE; *i. e.* "shame to him that thinks evil hereof." The meaning of which is, that King Edward, having laid claim to the kingdom of France, retorted shame and defiance upon him that should dare to think amiss of the just enterprize he had undertaken, for his recovering his lawful right to that crown, and that the bravery of those knights whom he had elected into this order was such, as would enable him to maintain the quarrel against those that thought ill of it.

The mantle is the chief of those vestments made use of upon all solemn occasions. The colour of the mantle is by the statutes appointed to be blue. The length of the train of the mantle only distinguishes the Sovereign from the knights companions. To the collar of the mantle is fixed a pair of long strings, anciently woven with blue silk only, but now twisted round, and made of Venice gold and silk, of the colour of the robe, with knobs, or buttons, and tassels at the end. The left shoulder of the mantle has from the institution been adorned with a large garter, with the device HONI SOIT, &c. within this is the cross of the order, which was ordained to be worn at all times by king Charles I. At length the star was introduced, being a sort of cross irradiated with beams of silver.

The collar is appointed to be composed of pieces of gold in fashion of garters, the ground enamelled blue, and the motto gold.

The manner of electing a knight com-

panion into this most noble order, and the ceremonies of investiture, are as follow: when the Sovereign designs to elect a companion of the garter, the Chancellor belonging to this order draws up the letters, which, passing both under the Sovereign's sign manual and signet of the order, are sent to the person by garter principal king at arms, and are in this manner, or to the same effect. "We, with the companions of our most noble order of the garter, assembled in chapter, holden this present day at our castle at Windsor, considering the virtuous fidelity you have shown, and the honourable exploits you have done in our service, by vindicating and maintaining our right, &c. have elected and chosen you one of the companions of our order. Therefore, we require you to make your speedy repair unto us, to receive the ensigns thereof, and be ready for your installation upon the——day of this present month, &c.

The garter, which is a blue velvet, bordered with fine gold wire, having commonly the letters of the motto of the same, is, at the time of election, buckled upon the left leg, by two of the senior companions, who receive it from the Sovereign, to whom it is presented upon a velvet cushion by garter king at arms, with the usual reverence, whilst the Chancellor reads the following admonition, enjoined by the statutes. "To the honour of God omnipotent, and in memorial of the blessed martyr St. George, tie about thy leg, for thy renown, this noble garter; wear it as the symbol of the most illustrious order, never to be forgotten, or laid aside; that thereby thou mayest be admonished to be courageous, and having undertaken a just war in which thou shall be engaged, thou mayest stand firm, valiantly fight, and successively conquer."

The princely garter being thus buckled on, and the words of its signification pronounced, the knight elect is brought before the Sovereign, who puts about his neck, kneeling, a sky-coloured ribbon, whereunto is appendant, wrought in gold within the garter, the image of St. George on horseback, with his sword drawn, encountering with the dragon. In the mean time, the Chancellor reads the following admonition: "Wear this ribbon about thy neck, adorned with the image of the blessed martyr and soldier of Christ, St. George, by whose imitation provoked, thou mayest so overpass both prosperous and adverse adventures, that having stoutly vanquished thy enemies, both of body and soul, thou mayest not only receive the praise of this transient combat, but be crowned with the palm of eternal victory."

Then the knight elected kisses the Sovereign's hand, thanks his Majesty for the great honour done him, rises up, and salutes all the companions severally, who return their congratulations.

GAS. This term was first applied by Van Helmont, to denote the permanently elastic exhalations afforded in chemical processes. Dr. Priestley, whose extensive and successful researches into this departmet of natural philosophy, in the space of a few years, produced a revolution in the science of chemistry, used the word air as the generic term for permanently elastic fluids. Other chemical writers of great reputation have thought fit to revive Van Helmont's term, and confine the word air to the atmospheric fluid. As this has been found convenient, to prevent confusion of ideas, it is now generally adopted; the gases which are not fully treated under the articles of their respective bases, will properly find a place here.

Gas, *ammoniacal*. See Ammonia.

Gas, *carbonic acid*. This is the first of the elastic fluids that appears to have been distinguished from common air, though its nature was not properly understood till it was investigated by Dr. Black. Its deadly properties, as it is met with in subterranean cavities, particularly the celebrated Grotto del Cano near Naples, occasioned it to be distinguished by the name of spiritus lethalis. Van Helmont first gave the name of gas, from a German word equivalent to our spirit, to this vapour produced from burning charcoal. He likewise called it spiritus sylvestris, and when arising from fermented liquors, spiritus vinosus. From its existing, in the inelastic state, in water, it was called fixed air, a name which Black and others long retained: Bewley termed it mephitic air, from its great abundance in nature combined with lime in the form of chalk, and it has been named the cretaceous and the calcareous acid, subsequent to the discovery of its acid nature. But carbonic acid has superseded all those, since it appears to have been ascertained that its radical is carbon. Of this, or rather of charcoal, according to the experiments of Lavoisier, it contains twenty eight parts by weight, to seventy-two of oxygen. Guy-

ton Morveau considers it as composed of 17.88 pure carbon, and 82.12 of oxygen.

Carbonic acid gas exceeds every other in specific gravity, except the sulphurous. Hence the vapour in the Grotto del Cano rises but a little above the surface; and the choak damp of miners, which is this gas, lies on the ground.—Thus, too, when it is emitted from a fermenting liquor, it first fills the empty portion of the vat, displacing the lighter atmospheric air; and then flows over the sides, almost as water would do. For the same reason, if a bottle filled with it be inverted over the flame of a candle at some distance, it will descend, and extinguish it. According to the experiments of Mr. Cavendish, one part of this, mixed with nine of atmospheric air, renders it incapable of supporting combustion.

From the powerful attraction of carbon for oxygen, the base of this gas is not easily decomposed; but Mr. Tennant effected it by introducing phosphorus into a coated glass tube, closed at one end, and over this powdered marble. A very small aperture only being left in the other end of the tube, and a red heat applied for some minutes, phosphate of lime and charcoal were found in the tube. Dr. Pearson did the same with phosphorus and carbonate of soda.

The carbonic acid gas is likewise decomposed in part by hydrogen gas, assisted by electricity. In a glass tube eight lines in diameter, De Saussure exposed a column of four inches in height of carbonic acid gas, and three inches of hydrogen gas, over mercury, to the action of the electric fluid circulating between iron conductors, for twelve hours. The gases were at first condensed very rapidly, but by degrees more and more slowly, till in this period they were reduced to four inches. Of this, one inch was absorbed by potash, being carbonic acid gas, and the other three were nearly pure carbonic oxide, the hydrogen having formed water with the oxygen, abstracted from the carbonic acid. The mercury and the conductors were but very little oxyded. De Saussure had previously found that carbonic acid and hydrogen gases, standing together over mercury for the space of a twelve-month, had decreased in volume.

Gas, *Carbonic oxide.* This gas was first made known by Mr. Cruickshank. Dr. Priestley had observed, that, when scales of iron mixed with charcoal, or with carbonate of barytes, were exposed to a strong heat, large quantities of a combustible gas were extricated, which he supposed to be heavy inflammable air, or carburetted hydrogen. He considered this as a strong argument against the modern theory of the formation of water; as, from the dryness of the ingredients, which were previously exposed to a red heat, and mixed and experimented upon immediately, and the quantity evolved, it could not be accounted for upon the supposition of the decomposition of water. This objection was successfully combated by Mr. Cruickshank, showing that the air did not contain hydrogen, but was an oxide of carbon. It is equally procured from the oxides of other metals, and charcoal; but in proportion to the facility with which these give up their oxygen, the carbon is more or less saturated with it; so that the product is a mixture of carbonic acid gas and carbonic oxide, the proportion of the former decreasing as the process is continued.

The carbonic oxide gas, freed from carbonic acid by washing with lime-water, is very little lighter than atmospheric air. It does not explode, when fired in atmospheric air, but burns with a blue lambent flame: with oxygen gas it detonates. It is noxious to animals. Water absorbs about a fifth only of its bulk. It is not absorbed by the pure alkalies, and does not precipitate lime-water. If it be mixed with hydrogen gas, and passed through an ignited glass tube, its oxygen unites with the hydrogen to form water, and charcoal is deposited. De Saussure, jun. however, ascribes this appearance of carbonaceous matter lining the tube to the action of the hydrogen on the lead in the glass, as he produced it by hydrogen alone with a glass tube; and could not by hydrogen and carbonic oxide in a tube of porcelain. The purest oxide of carbon is obtained, by passing the carbonic acid gas through red hot charcoal.

Gas, *hydrogen.* This is generally obtained from the reverse of the process for the decomposition of water. Iron moistened with water becomes oxyded, by decomposing the water; but this process is very slow. If the vapour of water be passed through a tube, containing iron wire, kept at a red heat, the decomposition will go on with much more celerity. But the readiest method is to employ an acid, as the sulphuric, diluted with five or six times its weight of water, poured on iron filings or turnings, or on zinc in small pieces. Zinc affords it the purest,

as that from iron is apt to be contaminated with carbon. Muriatic acid, diluted with twice or thrice its weight of water, may be employed, but it is less economical

Hydrogen gas is the lightest of all ponderable substances, particularly if received over quicksilver, and freed from any humidity which it may contain, by exposure to any substance that attracts water strongly. When perfectly dry, it is free from smell, but when it contains moisture, it is slightly fœtid. Though highly inflammable, it extinguishes burning bodies, if completely enveloped in it without the contact of oxygen. It is incapable of supporting life, but does not appear to possess any directly noxious quality, as it may be breathed for several respirations, or even nearly a minute. Fired, in combination with oxygen, it explodes very loudly; but if kindled as it escapes from the extremity of a capillary tube into the atmosphere, it burns calmly, with a white flame, the colour of which, however, may be varied by different substances dissolved in the gas. It is thus the philosophical fireworks without smoke or smell are formed. If a tube of glass, metal, or any elastic material, be held over a jet of inflamed hydrogen gas, musical tones will be produced, varying in depth and strength, according to the length, diameter, and material of the tube. A glass jar has a similar effect, but it must not be too wide, or so narrow as to extinguish the flame. Dr. Higgins first discovered this property.

A very high temperature is generally considered as necessary to produce the combination of hydrogen and oxygen. Biot compressed the two gases together in the syringe of an air gun; they took fire, exploded violently, and burst the syringe; but here the temperature was sufficiently increased by the pressure. A gentleman of Orkney, however, introduced nearly equal quantities of the two gases into a glass jar over mercury, which stood in a room without fire, and with little light, from the beginning of January to the end of May, when he found that, of twelve cubic inches, three and a half had disappeared. The residuum was still a mixture of the two gases.

The chief practical application of hydrogen gas is for the filling air-balloons.

Gas, *hydrogen arsenicated.* Scheele, dissolving tin in arsenic acid, observed the extrication of an inflammable gas, holding arsenic in solution. Proust afterwards obtained it by digesting arsenious acid and zinc in diluted sulphuric acid. It may be procured, likewise, by treating arsenious acid, or arsenic and iron fillings, or arsenic and tin filings, with muriatic acid; but still better by treating four parts of granulated zinc, and one of arsenic, with sulphuric acid diluted with twice its weight of water.

This gas is insoluble in water; does not render lime-water turbid; mixed with atmospheric air no diminution of bulk ensues, but the mixture, when fixed, detonates loudly, and deposits metallic arsenic; it has an alliaceous smell; it extinguishes burning bodies, and is fatal to animals; it is decomposed by oxygenated muriatic acid gas. If a lighted taper be immersed in a phial of this gas, it is instantly extinguished; but the gas burns at the mouth of the phial with a lambent white flame, which diffuses white fumes of arsenious acid. If it be inflamed in a phial with a small orifice, the flame gradually descends to the bottom of the phial, which becomes coated with crystallized metallic arsenic. Two parts of this gas, with one of oxygen, will explode loudly, and the products are water and arsenious acid; soap bubbles, made with a mixture of these gases, explode with a bluish white flame. Equal parts of the gases explode with a much more vivid flame, but less noise. A stream of this gas, burned in a large receiver filled with oxygen, emits a blue flame of uncommon splendour. According to Tromsdorff's calculation, a cubic inch of the gas contains about a quarter of a grain of the arsenic. Its specific gravity is rather more than half that of atmospheric air.

Gas, *carburetted hydrogen.* There are several varieties of this gas, the hydrogen holding different proportions of carbon in solution, according to the process by which it is obtained.

The gas of stagnant water, which may be procured by stirring the mud at the bottom with a stick, and collecting the gas, as it rises in bubbles, in an inverted bottle, is this compound, as is also the fire damp of coal mines. The vapour of water passed through a tube containing ignited charcoal consists of this gas and carbonic acid, which may be separated by agitating the mixture with lime diffused in water. The vapour of ether, or of alcohol, passed through a red hot tube of porcelain, coated with clay, affords the same products. If three parts of concentrated sulphuric acid, and one of alcohol, be distilled in a glass retort with a gentle heat, a carburetted hydrogen comes over. This is distinguished by the name of olefiant gas, from its property of forming an

oil on coming into contact with oxygenated muriatic acid gas. If five measures be mixed with six of the oxygenated muriatic gas, as rapid a dimunition takes place as when nitrous and oxygen gases are added to each other, and a thin film of oil forms on the surface of the water.

Mr. Henry examined these and some other varieties, as well as pure hydrogen, with a particular view to the light they were capable of affording; and the following are his tabulated results:

GASES.	Oxygen gas required to saturate 100 measures.	Measures of carbonic acid produced.
Pure hydrogen	50 to 54	. . . 0
Gas from moist charcoal	60 . . .	. . . 35
——— oak	54 . . .	. . . 33
——— dried peat .	68 . . .	. . . 43
——— coal	170 . . .	. . 100
——— lamp oil . . .	190 . . .	. . 124
——— stagnant water	200 . . .	. . 100
——— wax	220 . . .	. . 137
Pure olefiant gas . . .	284 . . .	. . 179

The light evolved appeared to be in proportion to the oxygen consumed, so that the first four in the list yielded very little; but the last much exceeded all the rest. Its detonation with oxygen gas too is more violent than that of any other inflammable gas .03 of a cubic inch, with 17 of oxygen gas, being sufficient to burst a strong glass tube.

About the year 1792, Mr. Murdoch made various experiments on the gas from coal, peat, and other substances, as a substitute for lamps and candles, both as fixed and as moveable lights, and in 1793 he applied it to the purpose of lighting the extensive manufactory at Soho. Light was procured by the same means several years ago at the ovens in Shropshire, for preparing coke and tar, on Lord Dundonald's plan. And six or seven years since a projector at Paris lighted up his house and gardens, and proposed to light the streets of the city in a similar way.

The varieties above enumerated differ in specific gravity, the olefiant gas being the heaviest, and that from charcoal the lightest. They differ likewise in the quantity absorbed by water, which takes up one-eighth its bulk of olefiant gas, one-sixty-fourth of that from stagnant pools, and still less of the others.

Gas, *phosphuretted hydrogen.* This may be procured by boiling in a retort a little phosphorus, with a solution of pure potash. The phosphorus should be first melted under water in the retort, which is to be emptied when the phosphorus has congealed, and then filled with the alkaline solution. Of this a sufficient portion is to be displaced by hydrogen gas. Or one part of phosphorus, cut into very small pieces, and two of finely granulated zinc, may be put into ten parts of water, and six parts of concentrated sulphuric acid added; the gas is disengaged in small bubbles, which cover the whole surface of the fluid, and take fire on reaching the air, so as to form by their succession a well of fire.

If two parts of phosphuret of lime, broken into pieces the size of a pea, and one of hyperoxymuriate of potash be put into an ale glass, or a Florence flask, the vessel be filled with water, and six or eight parts of concentrated sulphuric acid be poured in through a long-necked funnel reaching to the bottom, as soon as decomposition commences, flashes of fire will dart from the surface, and the bottom of the vessel will be illumined with a beautiful green light.

When phosphuretted hydrogen gas is suffered to escape into the air, as it issues from the retort it takes fire, and a dense white smoke arises, in the form of a horizontal ring, enlarging its diameter as it ascends. It detonates when mixed suddenly with oxygen, oxygenized muriatic acid, or nitrous oxide gas. By standing it loses its property of spontaneous ascension, the phosphorus being deposited on the inner surface of the vessel containing it.

Phosphuretted hydrogen gas may be dissolved in about four times its bulk of distilled water, at 44° Fahrenheit, and imparts to it a bitter taste, and strong unpleasant smell. This solution speedily converts the oxides of lead and mercury, and nitrate of silver, into phosphurets of those metals. Nitrates of lead, mercury, and arsenic, and sulphates of copper and iron, are acted upon by it more or less slowly; but some of the posphurets then formed are changed, by standing some time, into phosphates.

The ignis fatuus, or jack with a lantern, is supposed to be produced by this gas, arising from the putrefaction of animal substances in swampy places.

Gas, *sulphuretted hydrogen.* This gas, formerly termed hepatic air, may be obtained, by adding dilute muriatic acid to a solution of sulphuret of potash or of soda, which evolves it with violent effervescence; or by pouring diluted sulphuric or muriatic acid on sulphuret of iron. Sul-

phur and iron mixed together with a little water, likewise afford it by distillation.

Sulphuretted hydrogen is particularly characterized by its offensive smell, resembling that of rotten eggs. Like the other compounds of hydrogen, it detonates if mixed with oxygen or atmospheric air, and then fired, and burns silently, if inflamed as it comes in contact with them from a small aperture. If three parts of it be mingled with two of nitrous gas, the mixture burns with a yellowish green flame.

This gas is decomposed by oxymuriatic acid gas, by sulphurous acid gas, or by being kept mixed with atmospheric air, and its sulphur is precipitated. If passed through ignited charcoal, it is converted into carburetted hydrogen gas. It precipitates all metallic solutions, except those of iron, nickel, cobalt, manganese, titanium, and molybdæna. It tarnishes silver, mercury, and other polished metals, and immediately blackens white paint.

This gas is absorbed by water, which at 55° takes up .86 of its bulk, and at 85° only .78. The solution exposed to the air becomes covered with a pellicle of sulphur; and deposits sulphur even in well corked bottles. A few drops of nitric or nitrous acid likewise precipitate the sulphur.

It is remarkable that sulphuretted hydrogen, which contains no oxygen, consisting, according to Thenard, of 29 hydrogen, and 71 sulphur, should possess the properties of an acid, reddening litmus paper, and uniting with the alkalies and all the earths, except alumina and zircon. These compounds are soluble, and most of them are susceptible of crystallization. They are at first colourless, but by exposure to the air become green, or of a greenish yellow, and deposit sulphur. At length, however, the solution again becomes colourless, and the base is found ultimately converted into a sulphate. Acids disengage their sulphuretted hydrogen gas. Vauquelin, having lixiviated a considerable quantity of soda manufactured in France, found, after some weeks, a white transparent salt, crystallized in tetrahedral prisms, terminated by quadrangular or octangular pyramids. Its taste was acrid and intolerably bitter, and it had a slight hepatic smell. It did not precipitate any of the earthy salts, except those of alumina, zircon and yttria. Some of the German chemists have classed it as an acid, by the name of the hydrothian.

The waters called sulphurous, or hepatic, as those of Harrowgate, are solutions of this gas. They are recommended as alteratives in cutaneous affections, against worms, in gout and jaundice, and as deobstruents; but they are said to have been very injurious in dropsy.

Gas, *muriatic acid.* Muriatic acid exists in a separate state only in the form of gas, but its attraction for water is so strong, that it can be received and confined only over mercury. According to Kirwan, water absorbs rather more than 420 times its bulk, and is augmented by it about one third: in Dr. Thomson's experiments it took up 515 times its bulk at 60° Fahrenheit. It liquifies ice very rapidly, and the temperature is lowered. It has a pungent smell, is fatal to animals, and extinguishes flame, first imparting to it a greenish tinge. Its bulk is increased by a succession of electric shocks, which Mr. Henry has shewn to arise from the decomposition of water, of which he infers, from his experiments, 60 grains hold 1.4 in solutions. On its coming into contact with atmospheric air, a white cloud is produced. Brisson gives its specific gravity, atmospheric air being 1000, at 1430, Henry at 1730, Kirwan at 1929. For its other properties, see Muriatic Acid.

Gas, *oxygenized muriatic acid.* This gas, which is a compound of the preceding with oxygen, presents another anomaly in the theory of acidification; it was observed that sulphuretted hydrogen resembles an acid in many of its properties, though it contains no oxygen; and we here find the radical of an acid, which, with a certain proportion of oxygen, ranks among the most powerful, so much weakened in its properties, as even to be denied by some a place among the acids.

This gas is not invisible, as it has a greenish yellow colour. It has a pungent, suffocating smell, and is very injurious to the lungs; it extinguishes burning bodies; a temperature of 40° Fahrenheit reduces it to a liquid form. Mr. Northmore condensed nearly two pints in a receiver of the capacity of 2¼ inches, in which state it was a yellow fluid, so extremely volatile, as to evaporate the instant the screw of the receiver was opened. A pint of this gas being injected upon half a pint of oxygen, the result was a thicker substance, that did not evaporate so soon, and left a yellowish mass behind. Nitrogen in the same proportion gave a still thicker substance, and of a deeper yellow. In both these experiments much of the grease of the machine was carried down. Into a receiver, of three inches capacity, a pint of carbonic acid gas was pumped, and then rather more than a pint of oxygenized muriatic acid gas: the

result was of a sap green colour, but still elastic. Two pints of the gas with a pint of hydrogen was of a light yellow green, without any fluid, and highly destructive of colours.

This gas acts powerfully on various combustible bodies. If four parts of it, and three of hydrogen, be put into a bottle closely stopped, inverted, with its mouth under water, and the stopple be taken out in this situation after they have thus stood twenty-four hours, nearly the whole of the gas will have disappeared, and the remainder will be absorbed by the water. The hydrogen may be combined at once with the oxygen of this gas by the electric spark, which causes them to detonate. Phosphorus takes fire spontaneously in oxygenized muriatic acid gas; so do perfectly dry powdered charcoal of beech wood, and almost all the metals in fine filings, or very thin leaves. About a cubic inch of the gas is sufficient for a grain of metal; the bottom of the vessel should have a little sand on it, to prevent it from cracking; and the temperature should not be less than 70°. If a drachm of good ether be thrown into a three pint vessel filled with this gas, and the mouth covered with a piece of paper, a circulating white vapour will arise in a few seconds, which will soon be followed by an explosion with flame.

For the rest of its properties, see MURIATIC OXYGENIZED ACID, NITRIC ACID GAS, and NITRIC *acid*.

GAS, *nitric oxide*, or NITROUS GAS. We owe our first knowledge of this elastic fluid to Dr. Priestley, who called it nitrous air. It may be formed by passing ammoniacal gas through the black oxide of manganese, heated red hot in an earthen tube; but it is most easily obtained by abtracting a portion of its oxygen from nitric acid. For this purpose fine copper wire, or copper filings, may be put into a retort, with an equal weight of nitric acid, diluted with four or five parts of water, and moderate heat applied; or diluted only with an equal quantity of water, and no heat employed. After the atmospheric air is expelled from the retort, the gas that comes over may be received in the pneumatic apparatus. Other metals might be employed for the same purpose, but mercury and copper appear to afford it in the greatest purity; and the latter is perhaps preferable, because the process goes on more regularly with it.

This gas is colourless, and somewhat heavier than atmospheric air. It is extremely deleterious, killing even insects very quickly, and destroying plants. Water deprived of air absorbs about one-ninth of its bulk of this gas, without acquiring any taste from it; and a boiling heat expels it again unchanged. If the water contains air, the gas is partly decomposed, and the absorption, though in reality greater, is apparently less, from the nitrogen evolved. Water impregnated with earthy salts, does not absorb so much; a solution of green sulphate, or green muriate of iron, however, absorbs it rapidly, and becomes dark brown, and almost opaque. When this is effected over mercury, the gas may be expelled unchanged by a moderate heat, or by placing the solution in a vacuum, though perhaps not the whole of it. Solutions of nitrate of iron, the sulphates of tin, and of zinc, and muriate of zinc, likewise absorb it.

Nitrous gas has no acid properties. It does not redden vegetable colours, but impairs them. It extinguishes the flame of a candle, or burning sulphur, and the phosphoric light of animal substances: but lighted charcoal continues to burn in it; lighted phosphorus burns in it with great splendour, though, if not previously kindled, it may be melted or sublimed in it, without taking fire; and Homberg's pyrophorus kindles in it spontaneously. Its most important property is its affinity for oxygen gas, on account of which it was employed by Dr. Priestley, as it still is by many, to ascertain the quantity contained in atmospheric air. See EUDIOMETER.

When mixed with oxygen gas, red fumes arise, heat is evolved, and the two gases, if in due proportion and both pure, disappear, being converted into nitric acid.

This gas is soluble in nitric aaid, and alters its properties in some measure, without, however, converting it into an acid, in a distinct state of oxygenation, as some had supposed.

GAS, *nitrous oxide*. This is the gaseous oxide of nitrogen, or of azote of some; a compound of nitrogen with a still less proportion of oxygen than the preceding gas. It is not to be obtained certainly, with any purity, but by the decomposition of nitrate of ammonia. For this purpose, nitric acid, diluted with five or six parts of water, may be saturated with carbonate of ammonia, and the solution be evaporated by a very gentle heat, adding occasionally a little of the carbonate, to supply what is carried off. The nitrate crystallizes in a fibrous mass, unless the evaporation has been carried so far as to

leave it dry and compact. The latter at a heat between 275° and 300° sublimes without being decomposed; at 320° it becomes fluid, and is partly decomposed, partly sublimed: between 340° and 480° it is decomposed rapidly. The fibrous is not decomposed below 400°, but a heat above 450° decomposes it; at 600° a luminous appearance is produced in the retort, and nitric oxide, nitrous oxide, and nitrogen, mixed in various proportions, are evolved; at 700° or 800° an explosion takes place. It is best to perform the operation over an Argand's lamp, as the heat may thus be brought to the requisite degree speedily, and kept from going too far. It should be received over water, and suffered to stand an hour in contact with it, to free it from any nitrate of ammonia that may have been sublimed, as well as from any acid suspended in it. Dr. Pfaff recommends mixing very pure sand with the nitrate, to prevent the hazard of explosion; and observes, that it is particularly requisite it should not be contaminated with muriatic acid. One pound of the compact nitrate, yields 4.25 cubic feet of gas, and a pound of the fibrous nearly five cubic feet.

The most singular property of this gas is its action on the animal system. Dr. Priestley had found that it was fatal to animals confined in it. Mr. Davy first ventured to respire it, which he did to considerable extent. When breathed alone for a minute or two, and some have gone so far as four or five minutes, it generally produces a pleasant thrilling, particularly in the chest and extremities, frequently with an inclination to laugh, and sometimes an irresistible propensity to gesticulation and muscular exertion. The mind meanwhile is often totally abstracted from all surrounding objects. Sometimes its effects are not entirely dissipated for some hours; and it is remarkable, that, however strong they may have been, no sense of debility or langour is induced after they have subsided. On a few individuals, however, its effects have been unpleasant and depressing; in some it has produced convulsions, and other nervous symptoms; and on some it has had no sensible effect. Indeed, not only different persons, but the same individual, will be variously affected by it, perhaps, at different times. Similar effects have been produced on those who have tried it abroad.

In debility, arising from residence in a hot climate, and intense application to business, this gas has proved a complete remedy. It has given voluntary power over palsied parts while inhaled, and the subsequent application of other remedies has effected a cure. Dr. Pfaff has suggested its use in melancholia: but in some cases of this disease it has done no good, and in one harm.

Gas, *nitrogen or azotic.* Under the article Atmosphere it has been observed, that about three fourths of our atmosphere consist of gas, unfit to maintain combustion, or support life. It is called nitrogen or azotic gas, and is a little lighter than atmospheric air. It is incapable of supporting life, or combustion, yet a small portion is absorbed in respiration. It is not inflammable, though it unites with oxygen in different proportions, forming nitrous oxide, when the oxygen is only .37, nitric oxide when it is .56, and nitric acid when .705. It is one of the most general elements of animal substances. With hydrogen it forms ammonia; and Fourcroy suggested, that it might possibly be the alkaligenating principle, though he confesses there are no facts in support of this conjecture; the name of alkaligen, therefore, which has been proposed for it, is certainly inadmissible. It dissolves small portions of phosphorus, sulphur, and carbon.

Gas, *oxygen.* This gas was obtained by Dr. Priestley in 1774, from red oxide of mercury exposed to a burning lens, who observed its distinguishing properties of rendering combustion more vivid, and eminently supporting life. Scheele obtained it in different modes in 1775; and in the same year Lavoisier, who had begun, as he says, to suspect the absorption of atmospheric air, or, of a portion of it, in the calcination of metals, expelled it from the red oxide of mercury heated in a retort. Priestley called it dephlogisticated air; Scheele, from its peculiar property, fire air, a name before given it by Mayow, or empyreal air.

Oxygen gas forms about a fourth of our atmosphere, and its base is very abundant in nature. Water contains .85 of it, and it exists in most vegetable and animal products, acids, salts, and oxides.

This gas may be obtained from nitrate of potash, exposed to a red heat in a coated glass or earthen retort, or in a gun barrel, from a pound of which about 1200 cubic inches may be obtained; but this is liable, particularly towards the end

of the process, to a mixture of nitrogen. It may also be expelled from the red oxide of mercury, or that of lead; and still better from the black oxide of manganese, heated red hot in a gun barrel, or exposed to a gentler heat in a retort, with half its weight, or somewhat more, of strong sulphuric acid. To obtain it of the greatest purity, however, the hyperoxymuriate of potash is preferable to any other substance, rejecting the portions that first come over, as being debased with the atmospheric air in the retort. Growing vegetables, exposed to the solar light, give out oxygen gas; so do leaves laid on water in similar situations, the green matter that forms in water, and some other substances.

Oxygen gas has neither smell nor taste. It is a little heavier than atmospheric air; under great pressure, water may be made to take up about half its bulk. It is essential to the support of life; an animal will live in it a considerable time longer than in atmospheric air; but its respiration becomes hurried and laborious before the whole is consumed, and it dies; though a fresh animal of the same kind can still sustain life for a certain time in the residuary air.

Combustion is powerfully supported by oxygen gas; any inflammable substance, previously kindled, and introduced into it, burns rapidly and vividly. If an iron or copper wire be introduced into a bottle of oxygen gas, with a bit of lighted touch-wood or charcoal at the end, it will burn with a bright light, and throw out a number of sparks. The bottom of the bottle should be covered with sand, that these sparks may not crack it. Mr. Accum says a thick piece of iron or steel, as a file, if made very sharp at the point where it is first kindled, will burn in this gas. If the wire, coiled up in a spiral like a corkscrew, as it usually is in this experiment, be moved with a jerk the instant a melted globule is about to fall, so as to throw it against the sides of the glass, it will melt its way through in an instant, or if the jerk be less violent, lodge itself in the substance of the glass. If it be performed in a bell-glass set in a plate filled with water, the globules will frequently fuse the vitreous glazing of the plate, and unite with it, so as not to be separable without detaching the glaze, though it has passed through perhaps two inches of water.

As oxygen gas appears to be a very powerful stimulus to the animal economy, it has been applied medicinally; and is reported to have been of great service in many cases of debility, palsy, nervous affections, scrofula, rickets, and even hydrocephalus.

Gas, *sulphurous acid.* When sulphur is burnt slowly, as gas arises, of a suffocating pungent smell, consisting of sulphur combined with oxygen in less proportion than is requisite to form sulphuric acid. This was known to the earlier modern chemists, and Stahl examined some of its combinations; Priestley showed it was permanently elastic; Berthollet pointed out its difference from the sulphuric acid; and Fourcroy and Vauquelin completed its examination.

In the mode above mentioned, it is very difficult so to regulate the combustion as to obtain it free from sulphuric acid, which is formed when the sulphur burns with a certain degree of rapidity; so that it is commonly made by subtracting oxygen from sulphuric acid by some other inflammable substance. The metals answer the purpose, but such as do not decompose water should be employed, otherwise more or less hydrogen will be evolved. Tin or quicksilver answers best, one part of which may be put into a retort, with two of concentrated sulphuric acid, and heat applied. It should be received over mercury, as water absorbs it, taking up thirty-three times its bulk.

This gas is above twice as heavy as atmospheric air: it kills animals very speedily, and extinguishes burning bodies. From this latter property it has been recommended, when a chimney is on fire, to throw a spoonful or two of flowers of sulphur into the grate. It whitens and gives lustre to silk, and is useful in bleaching woollens. Fresh prepared muriate of tin decomposes it, sulphur being deposited, and the muriate oxygenized. Mr. Northmore has condensed it by pressure: and Monge did the same, with the addition of artificial cold. According to Dr. Thompson, it consists of sulphur sixty-eight parts, oxygen thirty-two.

One hundred grains of water take up 5 grains of this gas, or 25 parts by measure; or, according to Dr. Thomson, 8.2 grains, equal to 33 times its volume. The solution has a pungent disagreeable odour, and an acid taste. It reddens some of the vegetable colours, such as that of litmus, or red cabbage; there are others,

however, the colour of which it destroys, as that of the red rose. The effect of the gas upon these colours is similar.

The saturated solution allows the gas to escape at a very moderate heat, and by boiling, the greater part is expelled, though the liquor remains acid, apparently from the presence of sulphuric acid. It is singular that it is not expelled by freezing, but still remains combined with the ice, and renders it so heavy that it sinks in water. This act shows that that this has, comparatively with others, little tendency to pass into the aeriform state. The freezing of the solution takes place at a few degrees below 32.

When two parts of the gas are mixed with one part of oxygen gas, if the mixture is kept over mercury, they do not act on each other. But if a small portion of water is introduced, they gradually combine and form sulphuric acid, a fact explained by Mr. Murray, on the supposition that the water exerts a strong disposing affinity to this acid, or, to speak more intelligibly, according to the explanation of disposing affinity given under our article CHEMISTRY, the water attracts the sulphurous gas, and, by depriving it of its state of elastic fluidity, renders it capable of more readily uniting with the oxygen, which is also effected by a like action of the water; and as these combine into sulphuric acid, which is more soluble than the sulphurous, the process is still more facilitated, and goes on progressively until the effect is completed. By passing s mixture of oxygen gas and sulphurous acid gas through a tube heated to redness, they instantly combine, and sulphuric acid is formed.

This acid combines with facility with the alkalies, forming salts denominated sulphites, which differ considerably from the salts formed by the sulphuric acid. Their taste is sulphurous; they are decomposed by a high temperature, their acid being either expelled, or a portion of sulphur being driven off, in which case they become sulphates; they are also decomposed by the greater part of the acids, and then the sulphurous acid is disengaged with effervescence. The alkaline sulphites are more soluble than the sulphates in water, the earthy sulphates less so. All these salts are converted into sulphates by exposure to the atmospheric air, or by the action of any snbstance capable of affording them oxygen. They suffer this change, for example, by deflagration with nitre. See SULPHUROUS ACID.

TABLE,

Showing the absolute Weight and specific Gravities of Gases, and the Quantity of each absorbed by Water.

Temperature of 60° Fahrenheit, Barometer 29.8.

B. Brisson; Cr. Cruickshank; D. Davy; Dal. Dalton; Dei. Deiman; H. Henry; K. Kirwan; S. Shuckburgh; T. Thomson; Th. Thenard; Tr. Tromsdorff.

KIND OF GAS.	Weight of 100 cubic inches in grains.	SPECIFIC GRAVITY.			Number of cubic inches absorbed by 100 inches of water.	
		Water, the Standard at 1000.	Air, the Standard.	Authority.		
Nitric acid - - - -	76.	3.	2425	D.		
Sulphurous - - - -	70.215	2.75	2240	K.	3300.	T.
Vapour of ether - - -	62.1*	- - -	2250	K.		
Muriatic acid - - -	59.8	- - -	1929	Dal.		
Vapour of alcohol - -	51.5†	- - -	2100	Dal.		
Nitrous oxide - - -	50.1	1.985	1615	- -	86.	H.
Carbonic acid - - -	46.5	1.84	1500	K.	108.	H.
Ditto ditto - - - -	45.5	1.802	1470	D.		
Muriatic acid - - -	44.7 ?	1.765	1430	B.	51500.	T.
Sulphuretted hydrogen	38.17	- - -	1231	Th.		
Nitric oxide - - - -	37.	1.465	1193	K.	5.	H.
Nitric oxide - - - -	34.3	1.36	1105	D.		
Oxygen gas - - - -	34.74	1.39	1127	D.		
Sulphuretted hydrogen	34.286	1.36	1142	K.	108.	H.
Oxygen gas - - - -	34.	1.35	1103	K.	3.7	H.
Atmospheric air - -	31.	1.2279	1000	S.		
Azotic gas - - - -	30.535	1.21	985	K.	1.53	H.
Azotic gas - - - -	30.45	1.20	980	D.		
Carbonic oxide - - -	30.	1.185	967	Cr.	2.01	H.
Olefiant gas - - - -	28.18	- - -	905	Dei.	12.5	Dal.
Hydro carburet from stagnant water	20.66	- - -	666	Dal.	1.40	H.
Ditto from coal - - -	20.2	- - -	650	Dal.		
Ditto from ether - -	20.	- - -	645	Cr.		
Ammonia - - - - -	18.16	0.715	585	K.	47500.	D.
Ditto - - - - - -	18.	0.713	580	D.		
Arsenicated hydrogen gas	- - -	0.6499	529	Tr.		
Hydro carburet, from alcohol - - -	16.	- - -	516	Cr.		
Ditto from water over ignited charcoal	14.5	- - -	468	Cr.		
Hydrogen gas - - -	2.613	0.1031	84	K.	1.61	H.
Phosphuretted hydrogen	- - -	- - -	- -	- -	2.14	H

* Of temperature 100° Fahrenheit, and force = 30 inches of Mercury.
† Of temperature 190° Fahrenheit, and force = 30 inches of Mercury.

GASSENDI, (Peter,) in biography, a very eminent philosopher and mathematician, and one of the most illustrious ornaments of France, in the seventeenth century, was born in the year 1592, at Chanterseir, about three miles from Digne, in Provence. He afforded early evidence that he possessed a lively and inquisitive genius, and a happy memory, which determined his parents, though they were but in moderate circumstances, to bestow upon him the best education in their power. When he was only four years of age, in consequence of the pious impressions which had been made on his mind, he was accustomed to act the preacher among his playmates; and soon afterwards he began to discover his taste for astronomy, by taking delight in gazing at the moon and stars, when the atmosphere was unclouded.

The pleasure which he took in contemplating the heavens often led him to retire to unfrequented spots, where he might feast his eyes without being disturbed; by which means his parents were frequently obliged to seek for him, under anxiety and apprehensions for his safety. When he was of a proper age to be sent to school, he was placed under the instructions of an excellent master at Digne, where he made a rapid progress in the knowledge of the Latin tongue, and also acquired a pre-eminence over his school-fellows in rhetorical exercises. Afterwards he was sent to study philosophy for two years, under an able professor at Aix; and at the expiration of that period returned to his father's house at Chantersier.

He had not been long at home, however, before he was invited to teach rhetoric at Digne, when not quite sixteen years of age; and about three years afterwards he was appointed to fill the vacant chair of philosophy in the University of Aix. During his residence at Digne, he had sedulously prosecuted his studies in the learned languages, mathematics, and astronomy, and after a diligent examination of the different systems of philosophy among the ancients, embraced that of Epicurus, of which he afterwards proved himself the most ingenious defender in modern times. When he entered upon his philosophical professorship at Aix, notwithstanding that the authority of Aristotle was still acknowledged in almost all the public schools, Gassendi, after the examples of Vives, Ramus, and others, ventured publicly to expose the defects of his system. The lectures which contained his censures of the Aristotelian philosophy, delivered in the indirect form of paradoxical problems, were published under the title of "Exercitationes Paradoxicæ adversus Aristotelem." This work, which gave great offence to those who still retained their predilection for scholastic subtlety, obtained the author no small degree of reputation with several learned men, particularly with Nicholas Peiresc, the president of the University at Aix, who determined to procure for him a situation in the church, in which he should be enabled to pursue his favourite studies at his leisure, and without any molestation. After Gassendi had entered into holy orders, through the interest of Peiresc, and Joseph Walter, prior of Vallette, he was promoted to a canonry in the cathedral church of Digne, and admitted to the degree of doctor of divinity; and afterwards received the appointment of warden, or rector of the same church. In consequence of these promotions, he resigned his professorship at Aix, and retiring to Digne, applied himself closely to his philosophical and astronomical pursuits.

Among his other works which he wrote in this place, was a second book of his "Exercitationes Paradoxicæ," intended to expose the futility of the Aristotelian logic. It was his first intention to pursue the plan still further; but the violent opposition which he met with from some of the zealous and powerful advocates for the authority of Aristotle, induced him to desist from all direct attacks upon his philosophy. Still, however, he professed his attachment to the system of Epicurus, and defended it with great learning and ability.

From Lucretius, Laertius, and other ancient writers, he undertook to frame a consistent scheme of Epicurean doctrine, in which the phenomena of nature are immediately derived from the notion of primary atoms. But he was aware of the fundamental defect of this system, and added to it the important doctrine of a divine superintending mind, from whom he conceived the first motion and subsequent arrangement to have been derived, and whom he regarded as the wise governor of the world. He strenuously maintained the atomic doctrine, in opposition to the fictions of the Cartesian philosophy, which were at that time obtaining great credit; and particularly asserted, in opposition to Des Cartes, the doctrine of

a vacuum. On the subject of morals, he explained the permanent pleasure or indolence of Epicurus, in a manner perfectly consistent with the purest precepts of virtue. In the year 1628, Gassendi, for the sake of extending his acquaintance with the learned, visited Holland, where his philosophical and literary merit soon procured him many admirers and friends. While he was in that country he wrote an elegant and judicious apology for his friend, the learned Mersenne, in reply to the censures of Robert Fludd, on the subject of the Mosaic philosophy. After his return to France, he continued his philosophical, and particularly his astronomical studies, pursuing, with great care, a series of celestial observations, in order to complete his system of the heavens. Being called by a law-suit to Paris, he there formed an acquaintance with the men most distinguished for science and learning in that capital, and by his agreeable manners, as well as reputation, secured the esteem of persons of high rank and quality, and in particular of Cardinal Richelieu, and of his brother the Cardinal of Lyons. Owing to the application and interest of the latter, in the year 1645, Gassendi was appointed regius-professor of the mathematics at Paris. This institution being chiefly intended for astronomy, our author read lectures on that science to crowded auditories, by which he acquired great popularity, and rose to high expectations.—But the fatigues of that appointment were more than his strength, already reduced by too intense application, was able to bear; and having caught a cold, which brought an inflammation upon his lungs, he was obliged, in the year 1647, to quit Paris, and to return to Digne for the benefit of his native air. After having his health in some measure re-established by the intermission of his studies, in the year 1653 he returned again to Paris, where he published the lives of Tycho Brahe, Copernicus, Purbach, and Regiomontanus; and then resumed, with as much intenseness as ever, his astronomical labours. His feeble state of health, however, was now unequal to such exertions, which brought on a return of his disorder: under which, with the aid of too copious and numerous bleedings, he sunk in 1655, when in the sixty-third year of his age. A little before he expired, he desired his secretary to lay his hand upon the region of his heart; which when he had done, and remarked on the feeble state of its pulsation, Gassendi said to him, "You see how frail is the life of man!" which were the last words he uttered. He is ranked by Barrow among the most eminent mathematicians of the age, and mentioned with Galileo, Gilbert, and Des Cartes.

His commentary upon the tenth book of Diogenes Laertius affords sufficient proof of his profound erudition, and his deep skill in the languages.

We have already mentioned his opposition to the philosophy of Des Cartes, by which he divided with that great man the philosophers of his time, almost all of whom were either Cartesians or Gassendists. At one time a coolness took place between those two eminent characters, in consequence of irritating expressions which had escaped from both their pens, during the course of their philosophical warfare. The Abbé d'Estrees, afterwards Cardinal, with the design of bringing about a reconciliation between them, invited them both to dinner, in company with many of their common friends, among whom were father Mersenne, Roberval, the Abbé de Marolles, &c. At the time fixed, all the expected guests made their appearance, excepting Gassendi, who, during the preceding night, had been attacked by a severe complaint, which prevented him from venturing abroad. As the cause of his absence was explained after dinner, the Abbé d'Estrees carried his whole company along with him to Gassendi's apartments, where they had the pleasure of hearing the two philosophers make mutual acknowledgments of their improper warmth and irritability, and generously declaring, that whatever difference in opinion might afterwards subsist between them, it should produce no unfavourable effect upon their friendship.

Gassendi was the first person who observed the transit of Mercury over the sun. Kepler had predicted that it would take place on the 7th of November, 1631. Gassendi, who was then at Paris, made due preparations to observe it, and after having for some time mistaken the appearance of that planet for a solar spot, became at length sensible of his error by the rapidity of its movement; and took care to calculate the time of its egress from the sun's disk, as well as its distance from the sun's vertical point.

From Gassendi's letters, it appears that he was often consulted by the most celebrated astronomers of his time, as Kepler, Longomontanus, Snell, Hevelius, Galileo, Kircher, Bulliald, and others;

and his labours certainly entitle him to a high rank among the founders of the reformed philosophy. Gassendi possessed a large and valuable library, to which he added an astronomical and philosophical apparatus, which, on account of their accuracy and worth, were purchased by the Emperor Ferdinand III. and afterwards deposited, with other choice collections, in the Imperial Library at Vienna. The MSS. which he left behind him, and the treatises formerly published by himself, were printed together, accompanied by the author's life, and published by Sorbiere, in six volumes folio, 1658.—They consist of the philosophy of Epicurus; the author's own philosophy; astronomical works; the lives of Periesc, Epicurus, Copernicus, Tycho Brahe, Purbeck, Regiomontanus, John Muller, &c. a refutation of the meditations of Des Cartes; and epistles, and other treatises.

GASTEROSTEUS, the *stickle-back*, in natural history, a genus of fishes of the order Thoracici. Generic character: body carinate on each side, somewhat lengthened, and covered with bony plates; dorsal fin single, with distinct spines between it and the head; ventral fins behind the pectoral, but above the sternum. There are thirteen species. G. aculeatus, or three spined stickle-back, is found in almost all the fresh waters of Europe, and is about three inches long, and in the beginning of the summer displays the most beautiful combination of bright-red, fine olive green, and silvery whiteness. It is extremely active and rapid, and is particularly injurious in fish ponds, as it devours the spawn of the fish. It is highly voracious, and is reported to have swallowed in the space of five hours, seventy-four young dace, about a quarter of an inch in length. In the fens of Lincolnshire, these fishes appear in immense numbers, and have been frequently sold at the rate of a halfpenny per bushel. They have been often most successfully applied as manure for land.

GASTRIC *juice*, a fluid of the utmost importance in the process of digestion. It does not act indiscriminately on all substances, nor is it the same in all animals, nor does it continue always of the same nature, even in the same animal; it changes according to circumstances. No certain facts have yet been established as to the nature of the gastric juice: it is however completely ascertained, that it acts with a chemical energy in dissolving food: it attacks the surfaces of bodies, unites to the particles of them, which it carries off, and cannot be separated from them by filtration. It operates with more energy and rapidity the more the food is divided, and its action is increased by a warm temperature. The food is not merely reduced to very minute parts; its taste and smell are quite changed; its sensible properties are destroyed, and it acquires new and very different ones. This fluid does not act as a ferment, it is a powerful antiseptic, and even restores flesh already putriefied. Two things are well known with respect to the substances contained in the stomach. 1. They contain phosphoric acid; and 2. they have the power of coagulating milk, and the serum in the blood. What the coagulating substance is, has not been discovered, but it is supposed to be not very soluble in water, since the inside of a calf's stomach, after being steeped in water six hours, and then well washed, still furnishes a liquor, on infusion, which coagulates milk.

GASTROBRANCHUS, in natural history, a genus of fishes, of the order Cartilaginei. Generic character: mouth beneath, furnished with pectinal teeth, in a double row on each side: body eel-shaped, carinate beneath by a soft fin, two ventral spiracles. G. cœcus, or the hag-fish, is about five inches in length, in the European seas, but, in those of India, attains the length of a common eel. Its appearance is very similar to that of the lamprey. It is characterized by the circumstance of exhibiting no traces of the existence of such an organ as the eye. It is reported by naturalists, that the hag-fish will often enter the mouths of fishes fixed on the hook of the angler, and gnaw a passage through their bodies, devouring all but the bones and skin. Its substance is so highly glutinous, that a large vessel of sea water will, in a short time after the living cœcus is placed in it, become of the consistence of jelly.

GATE, in architecture, a large door, leading or giving entrance into, a city, town, castle, palace, or other considerable building: or a place giving passage to persons, horses, coaches, or waggons, &c

GAVELKIND, a tenure or custom belonging to lands in the county of Kent, by which the lands of the father are, at his death, equally divided among all his sons; or the land of a deceased brother, in case he leaves no issue, among all the brethren. This is by some called

ancient soccage-tenure: the custom came from our Saxon ancestors, among whom the inheritance of lands did not descend to the eldest, but to all the sons alike; and the reason why it was retained in Kent is, because the Kentish men were not conquered by the Normans in the time of William I.

The particular customs attending this tenure are, that the heir, at the age of fifteen, may give or sell his lands in gavelkind; and though the father is attainted of treason and felony, and suffers death, the son shall inherit. A wife shall be endowed of a moiety of the gavelkind-lands of which her husband died seised, during her widowhood. Likewise a husband may be tenant by courtesy of half his wife's lands, without having any issue by her; but if he marries again, not having issue, he forfeits his tenancy.

GAUGE-POINT, of a solid measure, the diameter of a circle, whose area is equal to the solid content of the same measure. Thus, the solidity of a wine-gallon being 231 cubic inches, if you conceive a circle to contain so many inches, the diameter of it will be 17.15; and that will be the gauge-point of wine-measure. And an ale-gallon, containing 282 cubic inches, by the same rule, the gauge-point for ale measure will be found to be 19.15. After the same manner may the gauge-point of any foreign measure be obtained; and from hence may be drawn this consequence, that when the diameter of a cylinder, in inches, is equal to the gauge-point of any measure, given likewise in inches, every inch in length thereof will contain an integer of the same measure, *e. gr.* in a cylinder whose diameter is 17.15 inches, every inch in height contains one entire gallon in wine measure; and in another, whose diameter is 18.95 inches, every inch in length contains one ale gallon.

GAUGER, a king's officer, who is appointed to examine all tuns, pipes, hogsheads, and barrels, of wine, beer, ale, oil, honey, &c. and give them a mark of allowance, before they are sold in any place within the extent of his office.

GAUGING, is the art of ascertaining the contents of casks, vats, and other regularly formed vessels, either in wine measure, which has 231 cubic inches to the gallon; in ale measure, which has 282 to the gallon; or in corn measure, which has 2150.42 cubic inches to the bushel. To find the contents of a vessel of a rectilinear form, you must ascertain the number of square inches on its surface, which being divided by the foregoing numbers (according as you use wine, ale, or corn measure,) will give the contents in gallons. But in this we suppose the vessel to be only one inch in depth; if more, the number of inches from the surface to the bottom must become a second agent in the calculation. Thus, if a cooler be a parallelogram of 250 inches long, and 84.5 broad, these measurements being multiplied together, will give an area of 21.125 inches, which being divided by 282, the number of inches in an ale gallon, the result will be 74.9 gallons: or if the product had been divided by .003546, the quotient would have been 74.90925, which is much the same. We have in this case supposed the area to have perpendicular sides, only one inch in depth. If the sides be six inches deep, the foregoing result, *viz.* 74.9, should be multiplied by 6; which would then give 449.4 gallons to be the measurement of the cooler. Where the sides shelve in, as in most tubs, or project out as in bell casks, regularly increasing or decreasing from the top to the bottom, the whole length at top and the whole length at bottom must be added together, and be halved, so as to give the medium length; and the same to find a medium of the two breadths at top and bottom. These mediums being multiplied together will give an area, which, being multiplied by the depth in inches, will shew the true contents, in either wine, ale, or corn measure, according to the divisor used. When the bottom shelves equally, the measurement at the centre will be a true medium; but if the bottom is uneven and irregular, you must take various measurements in different parts; then add the whole together, and divide by the number of measurements, or dips, and the quotient will, in general, be a fair medium. If the vessel is triangular, pentagonal, or anywise polyangular, the area must be ascertained by the ordinary rules in GEOMETRY, which see.

In circular vessels you must multiply the square of the diameter by .002785 for ale, or .003399 for wine: divide the former measure by 359.05, the latter by 294.12, and the quotients will be ale or wine gallons respectively.

Where you have an oval vessel to measure, ascertain the transverse or longest diameter, and the cojugate, or shortest diameter; multiply them together and divide as above.

Prismatic vessels are measured according to the first explanation, and frustrated or pyramidical vessels are disposed of in the same manner as those whose side or sides regularly augment, or *vice versa*. Truncated cones, likewise, come under the same rule; only treating their terminations as circles, instead of computing them as squares, or rectilinear bases. The following very easy mode of ascertaining the contents of a conic frustum is given by the ingenious Newton. Multiply each diameter (*i. e.* of top and bottom) by itself; then the one by the other, and the aggregate of those products by the altitude; multiply also the last product by 78539, (the superficial content of a circle whose diameter is 1000); a third part of the product is the measure of the frustum.

Therefore, when vessels have their sides composed of straight ribs, proceeding in right lines from one to the other end of the conic frustum, the measurement is easily made; thus we may, without difficulty, ascertain the contents of great coppers, mashing-tubs, corn-binns, and a great variety of similar vessels. But we rarely see casks of any description formed by the union of two frustrated cones; their usual shape is more spheroidal; that is, they have an arched or swelling course from the bung to the chimb or end; consequently these contain more than such as are truly conical. This occasions the necessity for allowing something for the bulge or swell, and of taking the diameter at the centre, between the bung and the chimb, which diameter will give a true medium. The thickness of the cask may easily be ascertained by aid of calibre compasses applied to the proper part. The length of the cask may be measured internally, by putting a rod or wand in at the tap hole, and the internal diameter may be taken in a similar way at the bung; but such can only be done when the cask is empty, or, at least, opened for the purpose: whereas casks that are filled and sealed must often be measured; for this purpose the calibre compasses are extremely useful, since they embrace the outside measure. To correct the computation, we must usually allow an inch and a half in the whole length, and the same in the whole diameters at the bung and chimb, thus exteriorly taken, for the thickness of the cask itself. This deduction being made, we must compute according to the form or swell of the staves. If they be much raised, we multiply the difference between the diameter at the bung, and at the end, by .7; if less raised, or swelling, we multiply the difference by .65; if nearly straight, by .6, and if rectilinear, or truly conical, by .55; the product added to the diameter at the end, or head, will give a mean diameter. Suppose the diameter within the bung to be 32 inches, at the head 24, and that the length within be 40; the difference between 32 and 24 is 8, which, multiplied by .7, gives 5.6; add thereto the diameter at the head, 24, and the medium will be 29.6; multiply by the length 40, and divide by 359.05, and the quotient will be ale gallons 97.4. And thus, with the other multipliers, according to the apparent bulge or swell between the bung and the chimb, and according to wine or ale measure.

To find the ullage, or quantity of liquor deficient in a cask, we have the following rule. Take the diameter at the bung, and ascertain the number of inches and parts that are dry; say that of 29 inches 13 be dry; also that the whole cask measures 80 gallons. Divide the dry inches 13 by 29, the bung diameter; the quotient will be .148; find the two first figures, .44 under V. S. in the annexed table, and its sequent will be .4238, to which add a proportional part for the 8, and the whole sequent will be .4343, which, multiplied by the contents of the cask, will shew a deficiency of 34.664 gallons. This measurement, however, applies to cylinders only; if the cask be conical, you must find the mean diameter, which should be deducted from that at the bung; and noting half the difference, which is to be deducted from the wet inches, and reserved. Then, as the mean diameter is to 100, so is the reserved difference to a versed line in the table: and if the segment (to be found in the table, be multiplied, as before shown, into the contents, the product will be the quantity of liquor in the cask.

Example. Let the bung-diameter be 32, the mean-diameter 29.6, and the whole measure 97.4 gallons: say there be 19 inches wet:

From 32.0	From 90
deduct 29.6	take 1.2
remain 2.4	remain 17.8 reserved.
its half is 1.2	

Now as 29.6 is to 100, so is 17.8 to .60, the versed sine. The segment to 60 is .6265; which, multiplied by 97.4, the whole contents, the product gives 61 gallons of liquor remaining. By working upon the dry inches, you would have found the ullage, or deficiency.

A TABLE of the Segment of a Circle, whose Area is Unity.

V. S.	Segment.	V. S.	Segment.	V. S.	Segment.	V. S.	Segment.
1	.0017	99	.9983	26	.2066	74	.7934
2	.0048	98	.9952	27	.2178	73	.7822
3	.0087	97	.9913	28	.2292	72	.7708
4	.0134	96	.9866	29	.2407	71	.7593
5	.0187	95	.9813	30	.2523	70	.7477
6	.0245	94	.9755	31	.2640	69	.7360
7	.0308	93	.9692	32	.2759	68	.7241
8	.0375	92	.9625	33	.2878	67	.7122
9	.0446	91	.9554	34	.2998	66	.7002
10	.0520	90	.9480	35	.3119	65	.6881
11	.0598	89	.9402	36	.3241	64	.6750
12	.0680	88	.9320	37	.3364	63	.6636
13	.0764	87	.9236	38	.3487	62	.6513
14	.0851	86	.9149	39	.3611	61	.6389
15	.0941	85	.9059	40	.3735	60	.6265
16	.1033	84	.8967	41	.3860	59	.6140
17	.1127	83	.8873	42	.3986	58	.6014
18	.1224	82	.8776	43	.4112	57	.5888
19	.1323	81	.8677	44	.4238	56	.5762
20	.1424	80	.8576	45	.4364	55	.5636
21	.1526	79	.8474	46	.4491	54	.5509
22	.1631	78	.8369	47	.4618	53	.5382
23	.1737	77	.8263	48	.4745	52	.5255
24	.1845	76	.8155	49	.4873	51	.5127
25	.1955	75	.8045	50	.5000	50	.5000

By such simple means we may ascertain the dimensions of most vessels in common use; we may, indeed, ordinarily estimate the diameters of casks to be in the proportion of 7 at the chimb for 10 at the bung, which gives a medium of 8.5.

But gaugers are, in general, provided with a neat, compact instrument, in form of a folding rule, whereby the measurement of a cask's interior may be taken with sufficient accuracy. This instrument consists of four pieces, each a foot long and about three-eighths of an inch square. It has three brass joints, for the purpose of folding. On one face is a double line of diagonals, one appropriated to wine, the other to beer measure. By inserting the lower end of the rod at the bung of the cask, and directing it obliquely so as to touch the junction of the head and stave, and noting the figures which stand opposite the centre of the interior of the bung-hole, the measurement is taken: in this process care must be taken to measure towards both chimbs, because a cask has not always the bung truly centrical: when any difference appears, the medium of the two measurements serves as a standard. Open vessels may be measured in the same way, by measuring the oblique line from the surface, or one side to the bottom of the other side; but only half the quantity shewn on the scale is to be taken for the contents. There is also a scale for cylindrical vessels, which shews the contents of one inch deep in any given area or diameter.

We must remark, that complete accuracy is not to be expected from this rod, however justly it may have been graduated: because the curves of staves, as has been shewn, vary so much, as to render some exclusive attention to that circumstance absolutely necessary; it being a point which cannot be determined by the rod or rule. The guagers in excise offices usually understand, at sight, if any unusual curve exists, and fail not to make allowance for such anomalies. The wine merchants, however, for many years, got the start of them, by causing the staves to be hollowed out considerably, indeed

as far as could be done with safety, leaving the bungholes and the ends of the staves of their ordinary thickness. By this device many gallons escaped paying duty while the vender, selling by the gallon, lost nothing, though he saved freight in proportion to the quantity of wood scooped from the interior face.

GAULTHERIA, in botany, a genus of the Decandria Monogynia class and order. Natural order of Bicornes. Ericæ, Jussieu Essential character: calyx, outer two-leaved, inner five-cleft; corolla ovate; nectary with ten dagger-points; capsule five-celled, covered with the inner calyx, now become a berry. There are two species.

GAURA, in botany, a genus of the Octandria Monogynia class and order. Natural order of Calycanthemæ. Onagræ, Jussieu. Essential character: calyx four-cleft, tubulous; corolla four-petalled, rising towards the upper side; nut inferior, one-seeded, four cornered. There is but one species.

GAUZE, in commerce, a thin transparent stuff, sometimes woven with silk, and sometimes only of thread. In preparing the silk for making gauze it is wound round a wooden machine six feet high, in the middle of which an axis is placed perpendicularly, with six large wings: on these the silk is wound on bobbins by the revolution of the axis; and when it is thus placed round the mill, it is taken off by means of another instrument, and wound on two beams. This is then passed through as many small beads as it has threads, and is thus rolled on another beam, in order to supply the loom. Gauzes are either plain or figured; the latter are worked with flowers of silver or gold, on a silk ground; and are chiefly imported from China. Gauzes of excellent quality have, of late years, been manufactured at Paisley.

GAZELLA. See Antelope.

GAZETTE, a newspaper, or printed account of the transactions of all the countries in the known world, in a loose sheet, or half sheet. This name is with us confined to that paper of news published by authority.

The first gazette in England was published at Oxford, the court being there, Nov. 7, 1665. On the removal of the court to London the gazette was published there. In this work are recorded all commissions and promotions in the army, all state appointments of consequence, with a variety of matters interesting to men of business and others.

GAZONS, in fortification, pieces of fresh earth, covered with grass, and cut in form of a wedge, about a foot long, and half a foot thick, to line the outsides of works made of earth, as ramparts, parapets, &c.

GELATINE, in chemistry, is one of the constituent parts of animal substances. Glue, well known in many of the mechanical and other arts, is gelatine, in a state of impurity, and may be obtained by repeatedly washing the fresh skin of an animal in cold water, afterwards boiling it, and reducing it to a small quantity, by slow evaporation, and allowing it to cool. It then assumes the form of jelly, and becomes hard and semi-transparent. Gelatine has neither taste nor smell; it is soluble in hot acids and alkalies; but there is no action between any of the earths and this substance. Some of the metallic oxides and salts form precipitates with gelatine in its solution in water, and the compound thus formed is insoluble. Gelatine forms a copious white precipitate with tan, which is brittle and insoluble in water, and is not changed by exposure to the air. It is composed of carbon, hydrogen, azote, and oxygen, with small portions of phosphate of lime and of soda. It is a principal part both of the solid and fluid parts of animals, and is employed in the state of glue, size, and isinglass. See Glue.

GELD, in our old customs, a Saxon word, signifying money, or tribute: also a compensation for some crime committed. See Gild.

GELLIBRAND, (Henry) an industrious English mathematician and astronomer, was born at London in the year 1597. When he was eighteen years of age he was admitted a commoner of Trinity College, in the university of Oxford, where, in the year 1619, he took his degree of B. A. At that time, Anthony Wood says, "He was esteemed to have no great matter in him;" but afterwards he conceived a strong inclination for the mathematics, upon accidentally hearing one of Sir Henry Saville's lectures in that science, and applied to it with considerable diligence and success. Having taken orders, he settled for some time as a curate at Chiddingstone in Kent; but his passion for mathematical studies determined him to quit that situation, and to return to the University, where he might uninterruptedly pursue the bent of his mind, supported by the moderate private patrimony which descended to him on the death of his

father. His sole attention was now devoted to the mathematics, in which he made such proficiency, at the time of his taking his degree of M. A. in 1623, that he attracted the notice and friendship of several able mathematicians who flourished at that time, particularly of the celebrated Henry Briggs, then Savillian professor of geometry at Oxford. While he continued in the pursuit of these studies, the professorship of astronomy in Gresham College, London, becoming vacant by the death of the ingenious Edmund Gunter, Mr. Briggs encouraged Mr. Gellibrand to become a candidate for that chair. Accordingly he proceeded to London, with strong testimonials in his favour from the President, Vice President, and Fellows of his College, and other active friends, and was chosen to fill that post by the electors, in the month of January, 1626. From that time he lived, as he had done before, in a close intimacy with Mr. Briggs, who took great pleasure in communicating to him his mathematical opinions and discoveries, and at the time of his death confided to him the task of completing his "British Trigonometry," which he did not live to finish. While Mr. Gellibrand was preparing that work for the press, he was cited, together with his servant William Beale, into the High Commission Court, by Doctor Laud, then Bishop of London, on account of an almanac for the year 1631, which Beale had published with the approbation of his master. In this almanac, the Popish saints usually put into the calendar were omitted, and the names of other saints and martyrs, mentioned in "Fox's Acts and Monuments of the Church," were inserted, as they stood in Fox's calendar. This circumstance gave great offence to the haughty prelate, and determined him to prosecute them for a measure, which he considered to be an unequivocal evidence of their Puritanism. But when their cause came to a hearing, by shewing that what they had done was no innovation, and pleading that they had no ill intention, they were acquitted by Archbishop Abbot and the whole court, Laud only excepted; which was made an article of accusation against the last-mentioned prelate at his own trial. This prosecution proved the means of retarding the publication of Mr. Briggs' work; but when Mr. Gellibrand had escaped from the vengeance of Laud, he again applied to the completion of his friend's design, and having added to it a preface, and the application of the logarithms to plane and spherical trigonometry, &c. constituting the second book of the work, the whole was printed at Gouda in Holland, under the care of Adrian Vlacq, in 1636. It was entitled "Trigonometria Britannica, sive de Doctrina Triangulorum, Libri duo, &c." folio.

Mr. Gellibrand, however, though an industrious mathematician, had not sufficient comprehension of mind to admit the evidence, which Galileo had lately produced in support of the Copernican system. This appears from the account which he has given of a conversation which he had, when he went over to Holland on the business of printing the Trigonometry, with Lansberg, an eminent astronomer in Zealand, who insisted on the truth of that system. "This, which he was pleased to style a truth," says our author, "I should readily receive as an hypothesis, and so be easily led on to the consideration of the imbecility of man's apprehension, as not able rightly to conceive of this admirable opifice of God, or frame of the world, without falling foul of so great an absurdity. Yet, sure I am, it is a probable inducement to shake a wavering understanding."

From Mr. Gellibrand's situation at Gresham College, and his intercourse with the lovers of mathematical studies, he had an opportunity of contributing some pieces, mentioned below, to the improvement of navigation, which science would probably have been farther benefitted by him, had he not been immaturely carried off by a fever in 1636, when in the fortieth year of his age. That his mathematical knowledge was considerable, and usefully applied, is sufficiently apparent from the treatises which he left behind him, and the estimation in which he was held by the most respectable men of science among his contemporaries, both at Oxford and London. But he is entitled more to the praise of close and unwearied industry than of invention or genius. Besides his part of the "Trigonometria Britannica," he was the author of "An Appendix concerning Longitude," subjoined to Captain Thomas James's Voyage for the Discovery of the North West Passage, 1633, quarto; "A Discourse mathematical, on the variation of the Magnetic Needle, together with the admirable diminution lately discovered," annexed to Wright's "Errors in Navigation Detected, &c." 1635,

quarto; "A preface to the Sciographia of John Wells, of Brembridge, Esq." 1635, 8vo; "An Institution, trigonometrical, explaining the doctrine of plane and spherical Triangles, after the most exact and compendious way, by Tables of Sines, Tangents, &c. with the application thereof to questions of Astronomy and Navigation," 1634, octavo; and afterwards republished with enlargements by William Leybourn, 1652, octavo; "An Epitome of Navigation, with the necessary tables," &c. and "An Appendix concerning the Use of the Quadrant, Fore-staff, and Nocturnal," octavo; "Oratio in Laudem Gassendi Astronomiæ, habita in Aula Ædis, Christi, Oxon;" and of several unpublished MSS. on the Doctrine of Eclipses, Lunar Astronomy, Ship Building, &c.

GEMINI, the Twins, in astronomy, one of the twelve signs of the zodiac, the third in order, beginning with Aries. See Astronomy.

GEMMA (Reinier), a learned Dutch physician and mathematician in the sixteenth century, was born at Dockum, in Friesland, in the year 1508. He was educated to the medical science, of which he became a professor in the university of Louvain. But he was particularly eminent for his proficiency in mathematics and astronomy, which he taught with distinguished reputation, and the character of being one of the best astronomers of his time. The fame of his great scientific knowledge, and of the excellent instruments which he made use of in the illustration of it, occasioned his being frequently invited to the court of the Emperor Charles V.; but he always modestly declined the overtures made to him, preferring the tranquillity of his literary retreat to the honours which he might expect from princely favour. He died at Louvain, in 1555, when only forty-seven years of age. He has sometimes had the surname of Frisclus given him, from the country in which he was born. The most celebrated of his works were "Methodus Artihmeticæ;" "De usu Annuli Astronomici;" "De Locorum describendorum Ratione, deque Distantiis eorum inveniendis;" "Libellus de Principiis Astronomiæ et Cosmographia," &c. "Demonstrationes Geometricæ de usu Radii Astronomici," &c.; and "De Astrolabio Catholico Liber."

The author had a son, named Cornelius, who was born at Louvain, in 1535, and died in 1579. He was a poet, philosopher, and physician, and taught the mathematical sciences at Louvain with considerable reputation. He was the author of "De Arte Cyclognomicæ," &c.; "De Naturæ divinis Characterismis, seu Cosmocritico;" and "De Prodigiosa Specie Naturaque Cometæ," occasioned by the extraordinary new star in the constellation Cassiopeia, in 1572, which disappeared after being visible for eighteen months; and other pieces.

Gemma, in botany, a bud, a compendium of a plant seated upon the stem and branches, and covered with scales, in order to defend the tender rudiments inclosed from cold, and other external injuries, till, their parts being unfolded, they acquire strength, and render any further protection unnecessary. Buds, together with bulbs, which are a species of buds, generally seated upon or near the root, constitute that part of the herb, by Linnæus called hybernacula; that is, the winter quarters of the future vegetable, as it is during that severe season that the tender rudiments are protected in the manner just mentioned. Plants, considered in analogy to animals, may properly enough be reckoned both viviparous and oviparous. Seeds are the vegetable eggs; buds, living fœtuses, or infant plants, which renew the species as certainly as the seed. In general, we may distinguish three kinds of buds; that containing the flower, that containing the leaves, and that containing both flower and leaves. The first contains the rudiments of one or several flowers folded over one another, and surrounded with scales. In several trees, this kind of bud is commonly found at the extremity of certain small branches, which are shorter, rougher, and less garnished with leaves than the rest. The external scales of this species of bud are harder than the internal; both are furnished with hairs, and in general more swelled than those of the second sort. The bud containing the flower, too, is commonly thicker, shorter, almost square, less uniform, and less pointed, being generally terminated obtusely. The second species of bud contains the rudiments of several leaves which are variously folded over one another, and outwardly surrounded by scales, from which the small stipulæ that are seated at the foot of the young branches are chiefly produced. These buds are commonly more pointed than the former sort. In the hazle-nut, however, they are perfectly round; and in horse-chesnut very thick. The third sort of bud is smaller than either of the preceding, and produces both flowers and leaves, though not always in the same manner. Sometimes the flowers and leaves

are unfolded at the same time. This mode of the flower and leaf-bud admits of the following distinctions from the sex of the flowers so produced with the leaves: male flower and leaf-buds as in the pine and fir-tree; female flower and leaf buds as in hazle-nut and horn-bean; hermaphrodite flower and leaf-buds as in the elm-tree, cornel-tree, mezereon, and almond tree.

GEMS certain stones, which, on account of their hardness, transparency, and beauty, when cut and polished, are highly esteemed, and, from their small size and scarcity, are valued at very considerable price. The gems have been placed among the siliceous fossils, as in some measure allied with them in external characters; and silex was supposed to be their principal ingredient. Bergman first shewed the error of this opinion, and proved, by analysis, that in the emerald, sapphire, topaz, ruby, and hyacinth, argil predominates; their other constituent principles, as discovered by his analysis, being silex, lime, and oxide of iron. Still, however, the old prejudice prevailed, and they have been generally ranked by mineralogists under the siliceous gems.

The specific distinctions of these fossils were not less osbcure; they were perplexed by the distinctions of the jewellers, drawn from very vague notions: the colour, in particular, being the property in which the gems differ most obviously, and which frequently gives them their mercantile value, served as a ground of distinction: hence the ruby, the sapphire, and the topaz, were considered as different, though essentially the same. Another circumstance, added to the confusion thus introduced, was, that other fossils, bearing a resemblance to these gems, had been classed with them; but, being inferior in lustre, transparency, and hardness, in order to distinguish between them, the epithet oriental was applied to those which were most perfect; and, by this contrivance, fossils were classed under one name, and regarded only as varieties of one species, which were totally different. The Oriental and the Saxon topaz, for example, were regarded under this point of view, or as varieties of one species, to which the common name of topaz belonged, though they are fossils altogether distinct. From these two circumstances, fossils were separated, which ought to have been associated, and others were connected, which were specifically different; and it has required much mineralogical discussion to disentangle the perplexity, and establish the proper species.

Romi de l'Isle threw the first ray of light on this subject, by disregarding the colour, and attending rather to the form of crystallization; in consequence of which he arranged together the principal gems named oriental, under the title of the oriental ruby. Werner also has placed them under one species, to which he gives the name of sapphire. Hauy has adopted the same arrangement, distinguishing the species by the name of télésie; and, more lately, Bournon has still farther extended the relations of these fossils, by connecting them with the corundum, a fossil which had been brought from India, and which, analysed by Klaproth, was found to be composed principally of argillaceous earth. This, having in general little transparency or lustre, Bournon names imperfect corundum; while the other variety, possessing these qualities, and comprising the oriental gems, is distinguished by the appellation of perfect corundum: these arrangements have received the sanction of chemical analysis. The skill of Klaproth, of Vauquelin, and Chenevix, has been exerted in investigating the composition of these fossils, and they have proved to be argil nearly pure. See DIAMOND, CORUNDUM, TELESIE, RUBY, SAPPHIRE, TOPAZ, AMETHYST, EMERALD, EMERY, BERYL, CHRYSOLTE, CHRYSOBERYLL.

GENDARMES, or GENS D'ARMES, in the French armies, a denomination given to a select body of horse, on account of their succeeding the ancient gendarmes, who were thus called from their being completely clothed in armour.

GENDER, among grammarians, a division of nouns, or names, to distinguish the two sexes.

GENEALOGICA *arbor*, or tree of consanguinity, signifies a genealogy or lineage drawn out under the figure of a tree, with its root, stock, branches, &c. The genealogical degrees are usually represented in circles, ranged over, under, and aside each other.

GENEALOGY, an enumeration of a series of ancestors; or a summary account of the relations and alliances of a person or family, both in the direct and collateral line.

GENERAL *of an army*, in the art of war, he who commands in chief.

A general ought to be a man of great courage and conduct, to have great experience, and to be of good quality. His conduct appears in establishing his magazines in convenient places; in examining the country, that he may not engage his troops too far while he is ignorant of the means of bringing them off; in subsisting them; and in knowing how to take the

most advantageous posts, either for fighting or shunning a battle. His experience inspires his army with confidence, and an assurance of victory; and his quality, by creating respect, augments his authority. By his liberality he gets intelligence of the strength and designs of the enemy, and by this means is enabled to take the most successful measures. A general ought likewise to be fond of glory, to have an aversion to flattery, to render himself beloved, and to keep a strict discipline.

The office of a general is to regulate the march and encampment of the army; in the day of battle to choose out the most advantageous ground; to make the disposition of the army; to post the artillery; and, where there is occasion, to send his orders by his aids-de-camp. At a siege, he is to cause the place to be invested; to order the approaches and attacks; to visit the works; and to send out detachments to secure his convoys.

General *issue*, in law, is that plea which traverses and denies, at once, the whole declaration or indictment, without offering any special matter, whereby to evade it: and it is called the general issue, because, by importing an absolute and general denial of what is alleged in the declaration, it amounts at once to an issue; that is, a fact affirmed on one side, and denied on the other. This is the ordinary plea upon which most causes are tried, and is now almost invariably used in all criminal cases. It puts every thing in issue, that is, denies every thing, and requires the party to prove all that he has stated.

It is a frequent question, what can be given in evidence by the defendant upon this plea, and the difficulty is, to know when the matter of defence may be urged upon the general issue, or must be specially pleaded upon the record. In many cases, for the protection of justices, constables, excise officers, &c. they are by act of parliament enabled to plead the general issue, and give the special matter for their justification under the act in evidence.

GENERATING *line* or *figure*, in geometry, is that by which its motion produces any other plane or solid figure. Thus, a right line moved any way parallel to itself generates a parallelogram; round a point in the same plane, with one end fastened in that point, it generates a circle. One entire revolution of a circle, in the same plane, generates the cycloid; and the revolution of a semi-circle round its diameter, generates a sphere, &c. See Cycloid, Sphere, &c.

GENERATION. See Physiology.

GENERICAL *name*, in natural history, the word used to signify all species of natural bodies, which agree in certain essential and peculiar characters, and therefore all of the same family or kind; so that the word used as the generical name equally expresses every one of them, and some other words, expressive of the peculiar qualities or figures of each, are added, in order to denote them singly, and make up what is called the specific name. Thus the word rosa, or rose, is the generical name of the whole series of flowers of that kind, which are distinguished by the specific names of the red-rose, the white-rose, the apple-rose, &c.

GENEVA, *gin*, a hot fiery spirit, too much used by the lower classes of people in this country as a dram, and is unquestionably most injurious to their constitution and morals. A liquid of this kind was formerly sold in the apothecaries' shops, drawn from the juniper-berry, but distillers have now completely supplanted the trade of the apothecary, who sell it under the name of Geneva, or gin, in which it is believed juniper-berries make no part of the composition. It is composed of oil of turpentine and malt spirits.—A better sort is said to be drawn off by a slow fire from juniper berries, proof-spirits, and water, in the proportion of three pound of berries to four gallons of water and ten of spirit. The celebrated Hollands geneva is manufactured chiefly at a village near Rotterdam, from the same materials, making use of French brandy instead of malt-spirits.

GENIOSTOMA, in botany, a genus of the Pentandria Monogynia class and order. Essential character: calyx turbinate, five-cleft; corolla one-petalled, with a villose throat, and a five-parted border; capsule oblong, two-celled, many seeded. There is but one species, a native of the isle of Tanna, in the South Seas.

GENISTA, in botany, a genus of the Diadelphia Decandria class and order. Natural order of Papilionaceæ or Leguminosæ. Essential character: calyx two-lipped, two and three-toothed; banner oblong, reflex downwards from the pistil and stamens. There are seventeen species.

GENIUS, in matters of literature, &c. a natural talent or disposition to do one thing more than another; or the aptitude a man has received from nature to per-

form well, and easily, that which others can do but indifferently, and with a great deal of pains.

GENTIAN, in pharmacy, is to be found in many countries, but particularly in some parts of France, on the Alps, Pyrenees, and the mountainous districts of Germany. That used in this country is mostly brought from Germany. The roots are the only part of the plant made use of in medicine. Gentian stands at the head of the stomachic bitters.

GENTIANA, in botany, a genus of the Pentandria Digynia class and order. Natural order of Rotaceæ. Gentianæ, Jussieu. Essential character: corolla monopetalous; capsule superior, two-valved, one-celled, with two longitudinal receptacles. There are fifty-three species.

GENUS, among metaphysicians and logicians, denotes a number of beings, which agree in certain general properties, common to them all; so that a genus is an abstract idea, expressed by some general name or term.

A genus is an assemblage of several species: that is, of several plants which resemble one another in their most essential parts. Hence it is aptly enough compared to a family, all the relations of which bear the same surname, although every individual is distinguished by a particular specific name. In botany the establishment of genera renders the subject more simple and easy, by abridging the number of names, and arranging under one denomination, termed the generic name, several plants, which, though different in many other respects, are found invariably to possess certain relations in those essential parts, the flower and fruit. Plants of this kind are termed by botanists plantæ congeneres, that is, plants of the same genus.

Linnæus's genera contain a description of each particular part of fructification, its various relations and different modes with respect to number, figure, situation, and proportion. Thus, all the different species of calyx, corolla, nectarium, stamina, &c. furnish the observer with so many sensible and essential characters. These characters the author denominates the letters or alphabet of botany. By studying, comparing, and, as it were, spelling these letters, the student in botany comes, at length, to read and understand the generical characters which the great Creator has originally imprinted upon vegetables: for the genera and species, according to Linnæus, are solely the work of nature; whilst the classes and orders are a combination of nature and art. Upon these principles, Linnæus, in his genera plantarum, determines the generical characters of all the plants there described.

Genus, in natural history, a sub-division of any class or order of natural beings, whether of the animal, vegetable, or mineral kingdoms, all agreeing in certain common characters.

GEOCENTRIC *latitude of a planet*, is its distance from the ecliptic as it is seen from the earth, which, even though the planet be in the same point of her orbit, is not constantly the same, but alters according to the position of the earth in respect to the planet.

Geocentric *place of a planet*, the place wherein it appears to us from the earth, supposing the eye there fixed: or it is a point in the ecliptic to which a planet seen from the earth is referred.

GEODÆSIA, the same with surveying. See Surveying.

GEOFFROYA, in botany, so named in honour of Monsieur Geoffroy, a member of the academy at Paris, a genus of the Diadelphia Decandria class and order. Natural order of Papilionaceæ or Leguminosæ. Essential character: calyx five-cleft; drupe ovate; nut flatted. There are two species.

GEOGRAPHY, is that science which exhibits the results of our investigations respecting the planet we inhabit, whether we consider its figure and the disposition of the lands and water upon its surface, or the subdivisions which the different nations who inhabit it have made, by which it is considered as forming kingdoms and states.

The general curvature of the earth's surface is easily observable in the disappearance of distant objects; and, in particular, when the view is limited by the sea, the surface of which, from the common property of a fluid, becomes naturally smooth and horizontal; for it is well known that the sails and rigging of a ship come into view long before her hull, and that each part is the sooner seen as the eye is more elevated.

On shore the frequent inequalities of the solid parts of the earth usually cause the prospect to be bounded by some irregular prominence, as a hill, a tree, or a building, so that the general curvature is the less observable.

The surface of a lake, or sea, must be always perpendicular to the direction of a plumb line, which may be considered as the direction of the force of gravity; and

by means either of a plumb line, or of a spirit level, we may ascertain the angular situation of any part of the earth's surface with respect to a fixed star passing the meridian: by going a little further north or south, and repeating the observation on the star, we may find the difference of the inclination of the surfaces at both points; of course, supposing the earth a sphere, this difference in latitude will be the angle, subtended at its centre by the given portion of the surface, whence the whole circumference may be determined, and on these principles the earliest measurements of the earth were conducted. The first of these which can be considered as accurate, was executed by Picart, in France, towards the end of the seventeenth century.

But the spherical form is only an approximation to the truth. It was calculated by Newton, and ascertained experimentally by the French academicians, sent to the equator and to the polar circle, that, in order to represent the earth, the sphere must be flattened at the poles, and prominent at the equator. We may therefore consider the earth as an oblate elliptic spheroid; the curvature being greater, and consequently every degree shorter at the equator, than nearer the poles. If the density of the earth were uniform throughout, its ellipticity, or the difference of the length of its diameters, would be $\frac{1}{230}$ of the whole; on the other hand, if it consisted of matter of inconsiderable density, attracted by an infinite force in the centre, the ellipticity would be only $\frac{1}{577}$; and whatever may be the internal structure of the earth, its form must be between these limits, since its internal parts must necessarily be denser than those parts which are nearer the surface. If, indeed, the earth consisted of water or ice, equally compressible with common water or ice, and following the same laws of compression with elastic fluids, its density would be several thousand times greater at the centre than at the surface; and even steel would be compressed into one-fourth of its bulk, and stone into one-eighth, if it were continued to the earth's centre: so that there can be no doubt but that the central parts of the earth must be much more dense than the superficial.

Whatever this difference may be, it has been demonstrated by Clairaut, that the fractions expressing the ellipticity, and the apparent diminution of gravity at the equator, must always make together $\frac{5}{576}$; and it has been found, by the most accurate observations on the lengths of pendulums in different latitudes, that the force of gravity is less powerful by $\frac{1}{180}$ at the equator than at the pole, whence the ellipticity is found to be $\frac{1}{320}$ of the equatorial diameter; the form being the same as would be produced, if about three-eighths of the whole force of gravity were directed towards a central particle, the density of the rest of the earth being uniform.

This method of determining the general form of the earth is much less liable to error and irregularity, than the measurement of the lengths of degrees in various parts, since the accidental variations of curvature produced by local differences of density, and even by superficial elevations, may often produce considerable errors in the inferences which might be deduced from these measurements. For example, a degree measured at the Cape of Good Hope, in latitude 33° south, was found to be longer than a degree in France, in latitude 56 north, and the measurements in Austria, in North America, and in England, have all exhibited signs of similar irregularities. There appears also to be some difference in the length of degrees under the same latitude, and in different longitudes. We may, however, imagine a regular elliptic spheroid to coincide very nearly with any small portion of the earth's surface, although its form must be somewhat different for different parts: thus for the greater part of Europe, that is, for England, France, Italy, and Austria, if the measurements have been correct, this oscillating spheroid must have an ellipticty of $\frac{1}{150}$.

The earth is astronomically divided into zones and into climates. The torrid zone is limited by the tropics, at the distance of 23° 28′ on each side of the equator, containing all such places as have the sun sometimes vertical, or immediately over them: the frigid zones are within the polar circles, at the same distance from the poles, including all places which remain annually within the limit of light and darkness, for a whole diurnal rotation of the earth, or longer: the temperate zones between these, have an uninterrupted alternation of day and night, but are never subjected to the sun's vertical rays. At the equator, therefore, the sun is vertical at the equinoxes, his least meridian altitude is at the solstices, when it is 66° 32′, that is, more

than with us at midsummer; and this happens once on the north, and once on the south side of the hemisphere. Between the equator and the tropics he is vertical twice in the year, when his declination is equal to the latitude of the place, and his least meridian altitudes, which are unequal between themselves, are at the solstices. At the tropics, the meridian sun is vertical once only in the year, and at the opposite solstice, or the time of midwinter, his meridian altitude is 43° 4′, as with us in April and the beginning of September. At the polar circles the sun describes, on midsummer-day, a complete circle, touching the north or south point of the horizon; and in midwinter he shews only half his disc above it, for a few minutes, in the opposite point; that is, neglecting the elevation produced by refraction, which, in these climates especially, is by no means inconsiderable. At either pole, the corresponding pole of the heavens being vertical, the sun must annually describe a spiral, of which each coil is nearly horizontal, half of the spiral being above the horizon, and half below; the coils being much more open in the middle than near the end.

The climates, in the astronomical sense of the word, are determined by the duration of the longest day in different parts of the earth's surface; but this division is of no practical utility, nor does it furnish any criterion for judging of the climate in a meteorological sense.

The natural division of the surface of the globe is into sea and land; about three-fourths of the whole being occupied by water, although probably no where to a depth comparatively very considerable, at most of a few miles on an average. The remaining fourth consists of lands, elevated more or less above the level of the sea, interspersed, in some parts, with smaller collections of water, at various heights, and in a few instances, somewhat lower than the general surface of the main ocean. Thus the Caspian Sea is said to be about three hundred feet lower than the ocean; and in the interior parts of Africa there is probably a lake equally depressed.

We cannot observe any general symmetry in this distribution of the earth's surface; excepting that the two large continents of Africa and South America have some slight resemblance in their forms, and that each of them is terminated to the eastward by a collection of numerous islands. The large capes projecting to the southward have also a similarity with respect to their form, and the islands near them; to the west the continents are excavated into large bays, and the islands are to the east: thus Cape Horn has the Falkland Islands; the Cape of Good Hope, Madagascar; and Cape Comorin, Ceylon, to the east.

The great continent, composed of Europe, Asia, and Africa, constitutes about a seventh of the whole surface of the earth: America about a sixteenth; and Australasia, or New South Wales, about a fiftieth; or in hundreth parts of the whole, Europe contains two; Asia, seven; Africa, six; America, six; and Australasia, two: the remaining seventy-seven being sea; although some authors assign seventy-two parts only out of one hundred to the sea, and twenty-eight to the land.

These proportions may be ascertained with tolerable accuracy by weighing the paper made for covering a globe, first entire, and then cut out according to the terminations of the different countries; or, if still greater precision were required, the greater part of the continents might be divided into known portions of the whole spherical surface, and the remaining irregular portions only weighed.

The general inclinations and levels of the continents are discovered by the courses of their rivers. Of these the principal are, the river of Amazons, the Senegal, the Nile, the river St. Lawrence, the Hoangho, the river La Plata, the Jenisei, the Mississippi, the Volga, the Oby, the Amur, the Oronooka, the Ganges, the Euphrates, the Danube, the Don, the Indus, the Dnieper, and the Dwina; and this is said to be nearly the order of their magnitudes. But if we class them according to the length of country through which they run, the order will, according to Major Rennel's calculation, be somewhat different; taking the length of the Thames for unity, he estimates that of the River Amazons at 15¾; the Kian Kew, in China, 15½; the Hoangho, 13½; the Nile, 12½; the Lena, 11½; the Amur, 11; the Oby, 10½; the Jenisei, 10; the Ganges, its companion the Burampooter, the river of Ava, and the Volga, each 9½; the Euphrates, 8½; the Mississippi, 8; the Danube 7; the Indus, 5½; and the Rhine, 5¼.

We may form a tolerable accurate idea of the levels of the ancient continent, by tracing a line across it in such a direction as to pass no river, which will obviously indicate a tract of country higher than

most of the neighbouring parts. Beginning at Cape Finisterre, we soon arrive at the Pyrenees, keeping to the south of the Garronne and the Loire.

After taking a long turn northwards, to avoid the Rhine, we come to Swisserland, and we may approach very near to the Mediterranean, in the state of Genoa, taking care not to cross the branches of the Po. We make a circuit in Swisserland, and pass between the sources of the Danube, and of the branches of the Rhine, in Swabia. Crossing Franconia, we leave Bohemia to the north, in order to avoid the Elbe; and coming near to the borders of Austria, follow those of Hungary to the south of the Vistula. The Dnieper then obliges us to go northwards through Lithuania, leaving the Don wholly to the right; and the Volga, to pass still further north, between Petersburg and Moscow, a little above Bjelosero. We may then go eastwards to the boundary of Asia, and thence northwards to Nova Zembla. Hence we descend to the west of the Oby, and then to the east of the branches of the Volga, and the other inland rivers flowing into the lake Aral and the Caspian Sea. Here we are situated on the widely extended elevation of India, in the neighbourhood of the sources of the Indus; and, lastly, in our way from hence towards Kamschatka, we leave the Jenisei and Lena on the left, and the Ganges, the Kiang Kew, the Hoangho, and the Amur, to the right.

The direction of the most conspicuous mountains is, however, a little different from this; the principal chain first constitutes the Pyrenees, and divides Spain from France; then passes through Vivarais and Auvergne, to join the Alps, and through the south of Germany to Dalmatia, Albania and Macedonia; it is found again beyond the Euxine, under the names of Taurus, Caucasus, and Imaus, and goes on to Tartary and to Kamschatka. The peninsula of India is divided from north to south by the mountains of Gate, extending from the extremity of Caucasus to Cape Comorin. In Africa, Mount Atlas stretches from Fez to Egypt, and the mountains of the Moon run nearly in the same direction: there is also a considerable elevation between the Nile and the Red Sea. In the new world, the neighbourhood of the western coast is, in general, the most elevated; in North America, the Blue Mountains, or Stony Mountains, are the most conisderable; and the mountains of Mexico join the Andes or Cordeliers, which are continued along the whole of the west c[own up by consi-] America. [dations, and]

There are several points, in[eration in] mispheres, from which we may o[e direc-] rivers separating to run to different s[nd ap] such are, Swisserland, Bjelosero, Tartar[ry] Little Tibet, Nigritia or Guinea, and Quito. The highest mountains are, Chimboracao, and some others of the Cordeliers in Peru, or perhaps Descabesado, in Chili, Mont Blanc, and the Peak of Teneriffe. Chimboracao is about seven thousand yards, or nearly four miles, above the level of the sea; Mont Blanc, five thousand, or nearly three miles; the Peak of Teneriffe, about four thousand, or two miles and a quarter; Ophir, in Sumatra, is said to be five or six hundred feet higher. It has, however, been asserted, that some of the snowy mountains to the north of Bengal are higher than any of those of South America. The plains of Quito, in Peru, are so much elevated, that the barometer stands at the height of fifteen inches only, and the air is reduced to half its usual density. But none of these heights is equal to a thousandth part of the earth's semi-diameter, and the greatest of them might be represented, on a six-inch globe, by a single additional thickness of the paper with which it is covered. Mount Sinai, in Japan, Mount Caucasus, Etna, the Southern Pyrenees, St. George among the Azores, Mount Adam, in Ceylon, Atlas, Olympus, and Taurus, are also high mountains; and there are some very considerable elevations in the island of Owyhee. Ben Nevis, in Scotland, is the loftiest of the British hills, but its height is considerably less than a mile.

The most elevated mountains, excepting the summit of volcanos, consist of rocks, more or less mixed, without regular order, and commonly of granite or porphyry. These are called primary mountains; they run generally from east to west in the old world, and from north to south in the new; and many of them are observed to be of easier ascent on the east than the west side. The secondary mountains accompany them in the same direction; they consist of strata, mostly calcareous and argillaceous, that is, of the nature of lime-stone and clay, with a few animal and vegetable remains, in an obscure form, together with salt, coals, and sulphur. The tertiary mountains are still smaller; and in these, animal and vegetable remains are very abundant; they consist chiefly of lime-stone, marble, alabaster, building-stone, mill-stone, and

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possible directions, and occupying vacuities, which appear to be of somewhat later date than the original formation of the mountains. The volcanic mountains interrupt those of every other description, without any regularity, as if their origin were totally independent of all the rest.

The internal constitution of the earth is little known from actual observation, for the depths to which we have penetrated are comparatively very inconsiderable, the deepest mine scarcely descending half a mile perpendicularly. It appears, that the strata are more commonly in a direction nearly horizontal than in any other; and their thickness is usually almost equable for some little distance; but they are not disposed in the order of their specific gravity, and the opinion of their following each other in a similar series, throughout the greater part of the globe, appears to rest on very slight foundations.

From observations on the attraction of the mountain Schehallien, Dr. Maskelyne inferred the actual mean density of the earth to be to that of water as four and a half to one, judging from the probable density of the internal substance of the mountain, which he supposed to be a solid rock. Mr. Cavendish has concluded more directly, from experiments on a mass of lead, that the mean density of the earth is to that of water as five and a half to one. Mr. Cavendish's experiments, which were performed with the apparatus invented and procured by the late Mr. Michell, appear to have been conducted with all possible accuracy, and must undoubtedly be preferred to conclusions drawn from the attraction of a mountain, of which the internal parts are perfectly unknown to us, except by conjectures founded on its external appearance. Supposing both series of experiments and calculations free from error, it will only follow, that the internal parts of Schehallien are denser, and perhaps more metallic, than was before imagined. The density assigned by Mr. Cavendish is not at all greater than might be conjectured from observations on the vibration of pendulums: Newton had long ago advanced it as a probable supposition, that the mean density of the earth might be about five or six times as great as that of water, and the perfect agreement of the result of many modern experiments with this conjecture affords us a new proof, in addition to many others, of the accuracy and penetration of that illustrious philosopher. See GLOBES.

GEOLOGY has for its object the structure and formation of this globe: it, of course, embraces the consideration of the materials of which it is composed, and the circumstances peculiar to its original formation, as well as the different states under which it has existed, and the various changes which it has undergone.

It necessarily follows, from the very limited depth within which our actual examinations have been made, that our facts and real observations are confined to what may be considered, comparatively, as merely the crust of the globe. With respect to its more internal part, we have hitherto only been aided by conjecture, which, it must be admitted, has too frequently led to theories the most extravagant and absurd. From the experiments of several learned men, it, however, appears, that the density of the globe is greatest towards its centre. Boscovich is of opinion, from his very ingenious calculations, that the centre is a spherical nucleus, possessing an equal degree of density to within some leagues of the earth's surface; but although it is thus concluded, that the interior of the earth is solid, contrary to the conjectures of several ancient philosophers, yet it is by no means pretended, that even in this, its more solid parts, there may not exist cavities of a greater or less size, connected, perhaps, with each other, and extending considerably, in all probability, towards the surface.

The solid masses of the globe, which have come within our examination, have been distinguished into primitive and secondary; among the former were placed the rocks of granite, gneiss, porphyry, serpentine, and limestone, of a peculiar character; and, among the latter, were considered the rocks of secondary limestone, of phosphate of lime, of gypsum, and of some of the sand-stones; of chalk, and of silex. This division is not, however, at present universally adopted; other divisions having been assumed, which have appeared to agree better with the different systems which have been proposed: these divisions we shall therefore more fully notice, after pointing out

the peculiarities of these several systems. The water is supposed, at present, to cover about three-fifths of the whole earth; but undoubted evidence exists, of its having extended over a much wider surface; and it is the opinion of many of the most eminent geologists, of its having covered the whole of the earth. As the necessity of ascertaining this latter circumstance is much urged, by those who have endeavoured to form correct opinions respecting the mode in which this globe was originally formed, it will be proper here to notice some of the evidence which has been adduced respecting this circumstance.

Herodotus relates, that, according to the priests of Vulcan, the whole of Egypt, except in the neighbourhood of Thebes, had been covered with water. Herodotus himself also noticed the existence, even in his time, of lakes of salt water in different parts of Egypt, as well as of the saline matter, mingled with the vast tracts of sand with which the country is covered; which observations are confirmed by the accounts that have been given, by those who have examined these parts in modern times. The diminution of the ocean is also rendered in the highest degree probable, from various facts related also by Strabo, Pliny, Diodorus the Sicilian, and several other early writers; and in the present day, the observations of Pallas, Celsius, Linnæus, and others, seem to establish the fact, of the diminution and sinking both of the Baltic and of the Caspian Seas.

On the other hand, innumerable facts may be adduced, which seem to prove that the water has actually increased, in its proportion, over the dry land. From the relations of Plaucus, Bryden, Barral, Fortis, and others, there can no doubt exist of the Mediterranean Sea having very much encroached on its shores; temples, and other edifices of different descriptions, which are known to have been erected at considerable distances from the sea, being now buried beneath its waves. In explanation of this varying evidence, it is necessary to state, although it may not affect the general question, that it cannot be doubted, that whilst the land is gaining on the sea, in some parts, similar encroachments are observable in others, of the sea on the dry land. Instances of this, on the small scale, may be observed on almost all flat, and on many precipitous shores: on the former, large embankments of sand are sometimes suddenly thrown up by considerable and violent inundations, and which, in consequence of alteration in the shape of the coasts, and of the direction of currents, may still remain, and appear to manifest an increase of the dry land; on precipitous shores, the reverse is observable; undermined by the continual and powerful action of the waves, large masses are perpetually falling, and, broken by their fall and by the action of the water, are so reduced as to easily allow of their removal by the waves: thus is occasioned a considerable reduction of the level of the shore; and thus an opportunity is given for the extension of the waters of the ocean on such particular spots. The balance, however, of this seemingly contradictory evidence is undoubtedly in favour of the opinion, that the water has considerably diminished, and is, perhaps, lessening at the present period.

Indubitable evidence of the water having stood over the tops of mountains, which are at present much above the level of the ocean, is yielded by the circumstance of various organized beings, former inhabitants of the water, being imbedded in these mountains, and even in their summits. Those who contend that the whole of the earth has been covered with water, have recourse to the testimony afforded by the several chemical and physical properties discoverable in the component parts of the loftiest mountains; and which prove, in their opinion, that all these substances have obtained their origin from the waters of the ocean, which they suppose to have invested the whole earth. This mode of the formation of rocks will not, however, be admitted by every geologist to be sufficiently ascertained, to allow of its being adduced as an evidence on the present occasion. That they have been thus produced, there appears, however, to be the greatest reason for supposing; but as their origin still remains a question with many, the testimony, on this occasion, must be proportionally weakened.

In the following sketch of some of the most interesting and important systems of the formation of the world, several facts will be noticed, from which additional evidence will be adduced, of not only the formation of the rocks from the contents of the primitive waters, but also of the waters having totally covered the earth; and since most of the important geological facts will come into consideration, whilst taking a view of the different

systems which have been offered of the formation of the world, and of the several changes which it has undergone, it is proposed to appropriate the remaining part of this article to that purpose.

Omitting to notice any further the scriptural account of the creation of the world, merely on account of the brevity of the narration preventing the disposal of the events there related in a systematic arrangement; we shall only here generally remark, that the occurrence of the most prominent circumstances related in that account has been repeatedly inferred by the most learned writers, who have endeavoured, from a view of the present state of the world, and of the various changes which it has undergone, to form some conjectures with respect to its original formation.

From the very imperfect accounts which have reached us, of the doctrines of the Egyptian philosophers on this subject, we can only learn, that they were of opinion, that, at the beginning, the water had covered the whole surface of the world; and that this was proved by the remains of organized beings, which were so frequently seen in the substance of the earth. These waters, it was supposed, had retired to the interior cavities of the globe, remaining in this great abyss, ready to issue out and produce the most extensive inundations; to one of which it was supposed that some of their records referred. The axis of the globe they believed to have been originally parallel with that of the plane of its orbit; and whilst it remained thus, they supposed that a perpetual spring existed, but that, on its inclining, an alteration of seasons took place.

The Chaldæans, like the Egyptians, are supposed, by Diodorus Siculus, to have believed the earth to be hollow; and that, in the early ages of its formation, a perpetual spring had existed. The Indians also believed in the existence of a vast abyss in the centre of the earth, for the reception of the water, which remained after the consolidation of the crust of the earth: they also believed in a general deluge of the earth, and in a subsequent retiring of the waters.

The opinions of the Epicureans, as delivered to us by Lucretius, appear to have been, that by the separation and appropriate re-union of accordant atoms, the different elements were formed, which, by the regulating influence of gravity, were separated from each other, and disposed in their allotted regions. One of the processes which was thus performed was the formation of the earth itself; which, being then variously acted upon, underwent those alterations of its surface, from which proceeded the vast cavities for the reception of the ocean, and those irregularities which divide its surface into hills and vallies.

Since several of the hypotheses of the formation of the world, and the changes which have brought it to its present state, deserve rather to be regarded as ingeniously devised allegories, than systems regularly deduced, it is not intended to do much more than specify those, the consideration of which will yield but little information. In agreement with this rule, we shall only state, respecting the hypothesis of Des Cartes, that he conceived that this globe might originally have been composed, like the sun, of the pure element (fire;) but that, by degrees, its less subtle parts had gradually collected together, and formed thick and obscure masses at its surface, similar to those accumulations which occasion the spots which we see on the sun. From the gradual, but, at length, complete incrustation thus formed, he supposed that the whole planet, at length, became covered and obfuscated; that, in this manner, different crusts were formed, and that, from the falling in of parts of the exterior crust into the cavity beneath, the irregularities of the earth's surface were produced.

To this hypothesis of Des Cartes, that of Leibnitz very nearly approaches; he supposed the crust, of which we have just spoken, to have been of a vitreous nature, the minute fragments of which are the sand that is every where so abundant. The affinity of our earth to the sun has been more strictly asserted by Buffon, who informs us, that the earth was originally separated from the sun, by the stroke which the sun received from the falling in of a comet; that this fragment, during its cooling, acquired, from its rotation, a spheroidal form, cavities being, at the same time, formed in its interior part, whilst its vapours condensed, and formed the waters of the ocean. Bicher entertained the o pinion, that there existed in the centre of the globe a cavity, which contained an accumulation of sulphurous, bituminous, and other mineral principles, which, raised in the state of vapours, by the internal heat, formed the various mineral substances which are contained in the substance of the earth. This hypothesis, so little supported by probabi-

lity, has been nearly adopted in modern times, by Gensanne, in his "History of Languedoc;" who imagines the existence of a central fire, by the influence of which numerous mineral principles are raised, in a state of vapour, through the different clefts of the earth, until they arrive near to its surface, where they enter into various combinations; the result of this is the production of the numerous mineral substances which the earth contains.

Besides these, who consider an inherent or central fire as necessary to the formation and continuation of this globe, there are others, who refer the particular modification of the form of its surface to the operation of subterraneous fires, acting partially by the incalescence of pyrites and volcanic eruptions, with accompanying earthquakes; amongst those who have adopted this opinion, may be mentioned Steno, Lazare, Moro, and Ray.

To produce the vast effects necessary to give form to a planet, or to modify its surface anew, must of course require the most powerful physical agents. In the various systems, therefore, which human ingenuity has devised, with the hope of pointing out the natural means which have been employed in these prodigious operations, the powerful agency of fire or of water has been generally referred to; and hence geologists have been rather whimsically named, according to the particular agency which they have supported in their discussions, Plutonists, and Neptunists. The systems already here noticed, it is obvious, are those in which fire has been adopted as almost the sole agent; in those which next will engage our attention, recourse has been had to the combined powers of both agents.

Dr. Burnet, whose system manifests a considerable portion both of ingenuity and judgment, supposes the earth to have originally been a fluid mass, the component parts of which became arranged according to their gravity; hence the heaviest matters were deposited at the centre, and above these were disposed, in concentric layers, the substances which were less and less heavy, and on the surface was the earth, covered all round by the water, which was itself invested by an unctuous matter, around which existed the circumambient air. By the subsequent intermixture of the oily matter and earth, and other arrangements of its several component parts, the crust of earth acquired a smooth form, and obtained those qualities which were necessary for the existence of organized beings. At this period, the axis of the globe was supposed to be parallel with that of its orbit, the days and the nights to be equal in length, and a uniform season to have existed, resembling a perpetual spring; but on the crust of the earth drying, from the ardency of the heat, it became violently rent asunder, falling into, and giving openings for the vast abyss of waters beneath: hence the axis of the globe became inclined, occasioning those changes of the seasons, and of the length of the days and nights which now exist; and thus also were produced the beds of the ocean, with the vallies and the numerous mountainous elevations.

Mr. Whiston conjectured, that the earth was originally a comet, which, at the period mentioned in the Mosaic account as that of the creation of the world, had its orbit rendered nearly circular, and such an arrangement formed of its component parts, as made it fit for the existence of the vegetable and animal creation: having existed in this state its allotted time, he supposes a comet to have passed so near to the earth, as to have involved it in the vapours forming its tail, and which, being condensed, fell in torrents, and produced the deluge described by Moses; the action of the comet on the earth itself having been sufficient to produce, at the same time, those irregularities of its surface, which form chains of mountains and the vast beds of the ocean.

Mr. Pallas, having assumed the formation of the sea and the primitive rocks, supposed that, with the sand produced by their constant disintegration, the sea must have deposited such inflammable and ferruginous matters, as, being disposed in beds on the granite, would form the fuel of volcanoes; these, raising and bursting the solid beds under which they had existed, and which they must have altered by fusion or calcination, would raise up the mountains of schist and of lime-stone. The shores of the sea being gradually augmented, the sea being diminished and driven back, whilst its bed was raised in different parts by the power of volcanoes, the formation of the mountains containing petrifactions would take place. Lastly, he supposed, after the earth had been well stocked with vegetables and animals, that by some enormous eruptions at the bottom of the sea, its waters may have been made to inundate the whole horizontal surface of the earth, and even those mountains which have not exceeded one hundred toises in height.

The system of Dr. Hutton resembles, in many points, that which has been just noticed; but its several parts are better connected, and it certainly possesses, al-

though in its tendency it is highly exceptionable, a more prepossessing appearance, since it ascribes the formation of continents, of mountains, vallies, &c. not to accidental occurrences, but to the operation of regular and uniform causes; making the decay of one part subservient to the restoration of another, by successive reproductions. Thus he supposes this globe to be regulated by a system of decay and renovation, and that these are effected by certain processes which bear a uniform relation to each other. The solid matter of the earth, especially of the rocks and high lands, he supposes to be perpetually separating by the reiterated action of air and water, and when thus detached, carried by the streams and rivers, and then deposited in the beds of the ocean. From these deposits, the various strata of our earth are supposed to be formed, obtaining their consolidation from the action of sub-marine fires; which, being placed at immense depths, must operate on these stratified depositions under the circumstance of vast pressure; by which volatilization must be prevented, and such changes produced, as would not otherwise be effected by the power of heat. The expansive power of subterraneous fire is called also in to explain, by the elevation of strata, their various positions. Thus, while the ocean is in one part removed by the accumulation and the elevation of strata, fresh receptacles are forming for it on other spots, where new strata will be deposited, rendered solid, and elevated.

According to this system, therefore, in the present world, which is made up of the fragments of those which preceded it, the materials are arranging for the formation of its successor; the system manifesting, as its author avowed, neither vestige of a beginning, nor prospect of an end.

Having thus sketched the outlines of the most interesting of the systems, which suppose the formation of this globe to have chiefly depended on the agency of fire, we shall now proceed to take a view of those in which the same effect is described as having been produced by the influence of water.

Woodward, with too little attention to facts, well known at the period at which he wrote, supposed that the solid parts of the earth were arranged in strata, according to their degrees of specific gravity; the water which had held them in solution having afterwards retreated to the grand abyss, which he supposed to exist in the centre. After some time, God ordained that the crust should break and fall into the abyss, and that the water should cover the surface. By the great solvent powers of this water, he supposed that every thing was again dissolved, and that afterwards they were again precipitated in concentric layers. The surface was then supposed to have been again broken, by which the waters again reached the centre, and the broken surface yielded those inequalities which now exist.

De Luc conceived, that in the beginning the sun did not exist in a luminous state, and that the earth, not feeling its influence, was frozen; but that, as the sun diffused its rays, the ice on the earth's surface became thawed, and penetrating inwards, dissolved the earth and other frozen matters to the depth of several leagues below the surface. But the thaw having reached this point, he supposes that the dissolved substances became either crystallized or precipitated, and that as they solidified they formed the primitive crust of the earth. After this, organized beings were created, many of which became involved in new strata, (the secondary) which were now formed at the bottom of the ocean; and the thawing of the internal parts of the globe continuing, cavities were formed, in consequence of the thawed substances possessing less space than they did whilst frozen. The whole of the crust, thus losing its support, sunk partially, at different periods, and the external water rushed in to fill the cavities which existed, and thus caused a considerable diminution of the waters which covered the earth; whilst, from the overturned fragments, arose the irregularities of the earth's present surface.

Led by the observation that the Alpine Mountains were frequently composed of strata obliquely disposed, Saussure imagined that the surface of the globe, formed by successive depositions and crystallizations, was originally covered by the ancient ocean; but that the crust bursting by the expansive force of heat, or of elastic fluids, the interior or primitive parts of the crust were turned outwards, and supported by those of secondary formation. By the rapid retreat of the waters into the cavities thus formed, he accounts for the enormous blocks, now lying in plains far distant from the rocks from which they were separated. After this retreat of the waters, he supposes that plants and animals were formed; and that since that period several immense currents have been caused by the opening of fresh gulfs, into which the waters have retreated at different periods; the last of

which being that which reduced the waters to their present level.

Patrin formed the opinion, that in the beginning all the matters which now compose the exterior part of the globe were held in solution, or suspension in a fluid; and that of these, some were deposited in a crytallized state, as the granite, &c. whilst those that were not in a state of actual solution formed the different schists, and other earthy, saline, and metallic strata, regularly and concentrically disposed. Whilst thus existing in a soft and yielding state, the different substances, by acting on each other, he supposes to have passed into a state of fermentation, necessarily productive of a swelling or raising up, which taking place first of all in the granitic and saline pasty masses, these were elevated, carrying with them, or bursting through the other strata, thus forming the rocks and mountains now existing on the face of the earth.

That respectable and excellent mineralogist, Mr. Kirwan, has zealously endeavoured to form a system which may accord with the Mosaic account of the creation. He supposes the superficial parts of the globe to have been in a fluid state, being held in solution by water considerably heated. From the coalescing and crystallization of the contents of this solution, the various metallic substances, the different earths, &c. were deposited in various combinations, forming, according to the predominant proportion of the ingredients, granite, gneiss, phorphyry, and the other primeval rocks. By the crystallization of these immense masses, a prodigious quantity of heat was generated, even to incandescence, and the oxygen uniting with inflammable air occasioned a stupendous conflagration; by this the solid basis on which the chaotic fluid rested was rent to a great extent. From the extrication, by this heat, of the oxygen and nitrogen gases, the atmosphere was formed: and from the union of the oxygen with ignited carbon, carbonic acid proceeded, which, being absorbed by calcareous earth, was precipitated in combination with it, forming the primitive lime stones. The level of the ancient ocean becoming then lowered to the depth of 9000 feet, fish were created; and the various stratified secondary mountains were formed within it during its retreat, and after the creation of fish. Soon after, the higher tracts of land being left uncovered by the retreat of the sea to its bed, the land became supplied with vegetables and animals. The deluge he considers as a miraculous effusion of water, both from the clouds and from the great abyss, which originated in, and proceeded from, the great southern ocean below the equator, and which, rushing into the northern hemisphere, descended southwards, and at length spread over the face of the whole earth.

M. de la Metherie, who has investigated the subject with much attention, is of opinion, that all the mountains, vallies, and plains, composing the crust of the earth, were formed nearly in the state in which they now exist, by crystallization of the mass of water which surrounded the earth. The matters composing the highest mountains, he shows, have evidently been held in solution: the water, therefore, must have reached above their summits, and of course have stood 18,000 feet, at least, above its present level. But this being admitted, it becomes necessary to determine what has become of the immense quantity of water which has disappeared since that period. Of this he imagines that some part has escaped by evaporation, and passed into other planets, but that by far the greatest part is buried in the immense caverns which exist in the interior part of the globe.

On reviewing the systems which have been just enumerated, it is obvious that some are so abundant in fanciful conjecture, and so deficient of probability, as not to require any further remark; whilst in others of a more specious appearance, there are some points which cannot be allowed to their ingenious authors. On these particular doubtful points, it is thought best to offer a few remarks, rather than separately examine each system. With respect to crystallization from an aqueous solution, a supposition which has not yet been generally adopted, it may be remarked, that the primitive mountains and vallies give exactly that irregularity of appearance, from lofty needle-like forms shooting up in some parts, and extensive plains existing in others, which are observable in cases of crystallization on the small scale. It has been objected, that the secondary mountains do not every where cover the primary on which they rest; this circumstance must, in all probability, have depended on particular local circumstances, and especially on such as would, as in ordinary cases of crystallization, direct the formation of crystals more numerously on one spot than on another. Particular currents may perhaps be considered among the causes which assisted in producing these effects, as well as in forming particular chains: whilst to the action of contrary currents

may be attributed the formation of separate mountains. The formation of secondary mountains seem also to concur with what is generally observed in the ordinary progress of crystallization, where it is observed, that after one series of crystals are formed of the least soluble matters, others are then formed of those substances which the fluid was able to hold still longer in solution. It has been objected against the system of crystallization of rocks, &c. that nature seems to perform nothing of that kind at the present period; but were this the fact, the objection would not possess much force, since a most satisfactory answer might be yielded, by asserting that the operation has ceased, in consequence of the task being accomplished; and, speaking with respect to the granitic and phorphyry rocks, all the materials being employed. The formation of stone by crystallization is, however, carrying on in various situations at the present moment; the incrustations formed in certain springs, and the various stalactitic formations which take place daily, are instances of this kind.

The unfitness of water to hold the substances forming the primitive rocks in solution has been considered as a powerful objection: but it is to be considered, that the menstruum cannot be supposed to have been simple water, but, as Mr. Kirwan observes, this primitive fluid must have contained all the various simple saline substances, and indeed every simple substance, variously distributed, "forming, upon the whole, a more complex menstruum than any that has since existed, and consequently endued with properties very different from any with which we have been since acquainted." Geological Essays, P. II.

Considerable difficulty must, however, continue, in adapting any system which confines the production of the various geological phenomena, which present themselves to our observation, to too few and to too limited causes; since, however necessary it may be to refer the general phenomena to the operation of one particularly powerful agent, it still must be necessary to take into the reckoning the sinking and the raising of particular spots from subterraneous submarine fires; as well as the changes produced by the subversion of lofty mountains, rapid and violent currents of water, and various other powerful causes.

By the preceding sketch of the numerous systems which have been advanced, and by these cursory remarks on some of the objections which have been made against those which appear to possess the greatest share of probability, the mind becomes better prepared to attend to the system of the celebrated Werner, to whom, in the opinion of his learned and zealous annotator, we owe almost every thing that is truly valuable in this important branch of knowledge. For the purpose of conveying some notion of this ingenious system, the following sketch is taken from the view of it, given in the "Elements of Geognosy," by Professor Jameson.

Agreeable to this system, the earth is supposed to have existed originally in a state of aqueous fluidity, which is inferred from its spheroidal form, and from the highest mountains being composed of rocks, possessing a structure exactly resembling that of those fossils, which have as it were, under the eye, been formed by water. From this circumstance it also follows, that the ocean must have formerly stood very high over these mountains; and as these appear to have been formed during the same period of time, it follows, that the ocean must have formerly covered the whole earth at the same time.—Contemplating the formations of the mountains themselves, Werner discovered the strongest proofs of the diminution of the original waters of the globe. He ascertained, 1st, that the outgoings (the upper extremities as they appear at the surface of the earth) of the newer strata are generally lower than the outgoings of the older, from granite downwards to the alluvial depositions, and this, not in particular spots, but around the whole globe. 2d. That the primitive part of the earth is entirely composed of chemical precipitations, and that mechanical depositions only appear in those of a later period, that is, in the transition class, and thence they continue increasing, through all the succeeding classes of rocks. This evidence of the vast diminution of the volume of water which stood so high over the whole earth is assumed to be perfectly satisfactory, although we can form no correct idea of what has become of it.

By the earliest separations from the chaotic mass, which are discoverable in the crust of the globe, was formed a class of rocks, which are therefore termed primitive rocks, being chiefly composed of silex, alumina, and magnesia, constituting, by their various intermixtures, 1, granite; 2, gneiss; 3, mica-slate; 4, clay-slate; 5, primitive lime-stone; 6, primi-

tive-trap; 7, serpentine; 8, porphyry; 9, sienite; 10, topaz rock; 11, quartz rock; 12, primitive flinty slate; 13, primitive gypsum; 14, white stone. The circumstances which chiefly mark the high antiquity of these rocks are, that they form the fundamental rock of the other classes; and that the outgoings of their strata are generally higher than those of the other classes. Having been formed in the uninhabitable state of the globe, they contain no petrifactions; and, excepting the small portions which sometimes accompany those which will be next mentioned, they contain no mechanical deposits, but are throughout pure chemical productions. Small portions of carbonaceous matter occur only in the newer members of the class.

Before the summits of the mountains appeared above the level of the ocean, and before the creation of vegetables and animals, a rising of the waters is supposed to have taken place, during which that class of rocks which are said to be of the second porphyry and sienite formation was deposited. The rocks of this formation are of clay-porphyry, pearl-stone porphyry, obsidian porphyry, sienite, and pitch-stone. They contain very little mechanical depositions, are of complete chemical formation, and contain little or no carbonaceous matter, and never any petrifactions.

On the appearance of land, or during the transition of the earth from its chaotic to its habitable state, rocks, which, from this circumstance, are denominated transition rocks, were formed. In these rocks the first slight traces of petrifactions, and of mechanical depositions, are to be found. The species of rocks which come under this class are, the transition lime-stone, transition-trap, gray-wacke, and flinty slate. The petrifactions are, corallites, encrinites, pentacrinites, entrochites, and trochites. The lime-stone of Derbyshire is said to be of this kind. As the former class of rocks were purely of chemical formation, so the contents of these are chiefly chemical productions, mingled with a small proportion of mechanical depositions. To explain the cause of this mixture we are referred to the period of their formation, that at which the summits of the primitive mountains just appeared above the waters, when, by the attrition excited by the motion of the waves, and which we are reminded extends to no great depth, particles of the original mountains were worn off and deposited.

As the height of the level of the ocean diminished, so would the surface on which its waves acted increase, and of course the quantity of the mechanical depositions. Hence these are much more abundant in the rocks of the next formation, which are denominated flœtz rocks, on account of their being generally disposed in horizontal or flat strata. In these, petrifactions are very abundantly found, having been formed whilst vegetables and animals existed in great numbers. These rocks are generally of very wide extent, and commonly placed at the feet of primitive mountains. They are seldom of very great height, from whence it may be inferred, that the water had considerably subsided at the time of their formation, and did not then cover the whole face of the earth. Countries composed of these rocks are not so rugged in their appearance, nor so marked by rapid inequalities, as those in which the primitive and transition rocks prevail. The formations of this class are supposed to be, 1, first or old red sand-stone; 2, first or oldest flœtz lime-stone; 3, first or oldest flœtz gypsum; 4, second or variegated sand-stone; 5, second flœtz gypsum; 6, second flœtz or shell lime-stone; 7, third flœtz sand-stone; 8, rock-salt formation; 9, chalk formation; 10, flœtz-trap formation; 11, independent coal formation; 12, newest flœtz-trap formation.

Most of the rocks which have been just enumerated are covered by a great formation, which is named the newest flœtz-trap. This formation also covers many of the high primitive mountains: it has but little continuity, but is very widely distributed. It contains considerable quantities of mechanical deposits, such as clay, sand, and gravel. The remains both of vegetables and animals also occur very abundantly in these deposits. Heaps of trees and of parts of plants, and an abundance of shells and other marine productions, with the horns of stags, and great beds of bituminous fossils, point out the lateness of the period when this formation was deposited. In this formation several rocks occur, which are also met with in other flœtz formations; but the following are supposed to be peculiar to this class, basalt, wacke, gray-stone, porphyry, slate, and trap tuff. These rocks are said to have been formed during the settling of the water consequent to a vast deluge, which is supposed to have taken place when the surface of the earth was covered with animals and vegetables, and when much dry land existed. From various ap-

pearances observed in these rocks it is concluded, that the waters in which they were formed had risen with great rapidity, and had afterwards settled into a state of considerable calmness.

The collections and deposits derived from the materials of pre-existing masses, worn down by the powerful agency of air and water, and afterwards deposited on the land or on the sea coasts, are termed alluvial, and are, of course, of much later formation than any of the preceding classes. These deposits may be divided into, 1. Those which are formed in mountainous countries, and are found in vallies, being composed of rolled masses, gravel, sand, and sometimes loam, fragments of ores, and different kinds of precious stones. 2. Those which occur in low and flat countries, being peat, sand, loam, bog iron oar, nagelflech, calc-tuff, and calc-sinter: the three latter being better known by the names breccia, tufa, and stalactite.

In this ingenious system, in which so much knowledge of the subject prevails, and in which the marks of long and patient investigation are evident, a very close accordance with geological facts is generally observable. Some few difficulties however occur, particularly it seems with respect to the new trap formation; since, although the appearances which this is intended to explain do not better agree with any other supposition, still the rising of the waters, whilst they yet covered the summits of primitive mountains, has much the appearance of a supposition made up for this particular purpose; and as, at the same time, it appears to be warranted by no other phenomena, it seems to require some further consideration, before it is fully admitted.

For more particular observations on the various characters, and on the different classes of rocks, see ROCKS.

GEOMETRA, in natural history, one of the families of the Phalæna genus of insects. See PHALÆNA.

GEOMETRY, in its original sense, related simply to the measurement of the earth, and was invented by the Egyptians, whose lands being annually inundated, required to be frequently measured out to the respective owners, so that each might repossess his property. It seems probable, that in the operations attendant on that act of justice, many discoveries were made relating to the properties of figures, which gradually led on to an extension of the science, and to the cultivation of the arts of navigation and astronomy, which, indeed, first flourished in that quarter. We are rather in the dark as to many improvements made in the infancy of geometry, and its attendant speculations; many tracts of supposed value having been entirely lost, though some faint traces and fragments of their subjects, if not of their contents, have from time to time been discovered. The Grecians appear to have been enthusiasts in their reception of the new science; accordingly we find that Thales, Pythagoras, Archimedes, Euclid, &c. exerted themselves to instruct their countrymen, and thus to prepare the way for the philosophy of Ptolemy, Copernicus, and others of the ancient school; and of Des Cartes, Leibnitz, and the immortal Newton, in our more enlightened times. At present, geometry is justly considered to be the basis of many liberal sciences, and to be an indispensable part of the education of those who purpose exercising even the more mechanical arts to advantage.

We shall submit to our readers a general view of this most useful and fascinating attainment, and, by a gradual display of its rudiments, open the field to further advancement, which may be easily insured, by consulting those authors who have become eminent for the display of whatever relates to the superior branches of geometry. In the first instance, we shall submit the following definitions, as laid down by Euclid in his Elements, recommending them to the serious attention of the student; they being absolutely necessary towards his competent appreciation and understanding of the succeeding propositions.

DEFINITIONS.

1. A point hath neither parts nor magnitude. 2. A line has length, without breadth. 3. The ends, or bounds, of a line are points. 4. A right line lies evenly between two points. 5. A superficies or plane has only length and breadth. 6. Planes are bounded by lines. 7. A plain superficies lies evenly and level between its lines. 8. A plain angle is formed by the meeting of two right lines. 9. When an angle measures 90 degrees, it is called a right angle. 10. When less than 90 degrees, it is said to be an acute angle. 11. When more than 90 degrees, it is called an obtuse angle. 12. A term, or bound, implies the extreme of any

thing. 13. A figure is contained under one or more bounds. 14. A circle is a plain figure, contained in one line, called the circumference, every where equally distant from a certain point within it. 15. That equi-distant point within the circle is called its centre. 16. A line passing from one side to the other of a circle, and through its centre, is the greatest line it can contain, and is called its diameter. 17. The diameter divides the circle into two equal and similar parts, called semi-circles. 18. When a line shorter than the diameter is drawn from one point to another on the circumference of a circle, it is called a chord. 19. The part of the circle, so cut off or divided by such line or chord, is called an arc or segment. 20. Figures contained under right lines are called right-lined figures. 21. A figure having three sides is called a triangle. 22. If all the sides of a triangle are of the same length, it is called an equilateral triangle. 23. If all the sides and angles are unequal, it is called a scalene triangle. 24. If two of the sides are of equal length, it is called an isosceles, or equi-crural triangle. 25. If containing a right angle, it is called a right-angled triangle. 26. The long side subtending, and opposite to, the right angle, is called the hypothenuse. 27. When the two shortest sides of a triangle stand at a greater angle than 90 degrees, the figure is said to be "obtuse;" and when all the angles are acute, it is called an acute-angled triangle. 28. When two lines preserve an equal distance from each other in every part, they are said to be parallel. 29. Parallel lines may be either straight or curved, but can never meet. 30. A figure having four equal sides, and all the angles equal, is a square. 31. But if its opposite angles only be equal respectively, the figure will then be a rhombus, or lozenge. 32. When all the sides of a figure are right lines, and that the opposite sides are parallel and equal, it is called a parallelogram. 33. If the opposite sides are equal, the others being unequal, the figure is called a rhomboides. 34. Four-sided figures unequal in all respects, are called trapesia. 35. Figures having more than four sides are called polygons, and are thus distinguished: with five sides, it is called a pentagon; with six, an hexagon; with seven, an heptagon; with eight, an octagon; with nine, an enneagon; with ten, a decagon; with eleven, an endecagon; with twelve, a dodecagon. 36. A solid has length, breadth, and thickness. 37. A pyramid is a solid standing on a base, of any number of sides, all of which converge from the base to the same point or summit. 38. When standing on a triangular base, it is called a triangular pyramid; on four, a square pyramid; on five, a pentagonal; and thus in conformity with the figure of its base. 39. Every side of a pyramid is a triangle. 40. A cone is found by the revolution of a triangle on its apex, or summit, and a point situated in the centre of its base; therefore a cone (like a sugar-loaf) has a base, but no sides. 41. A prism is a figure contained under planes, whereof the two opposite are equal, similar, and parallel; and all the sides parallelograms. 42. A sphere is a solid figure, generated by the revolution of a circle on its diameter, which is then called the axis. 43. A cube is a solid formed of six equal and mutually parallel sides, all of which are squares. 44. A tetrahedron is a solid contained under four equal, equilateral triangles. 45. A dodecahedron is a solid contained under twelve equal, equilateral, and equiangular pentagons. 46. An icosahedron is a solid contained under twenty equal, equilateral triangles. 47. A parallelopipedon is a figure considered under six quadrilateral figures or planes, whereof those opposite are respectively parallel. 48. Figures, or bodies, are said to be equal, when their bulks are the same; and similar, when they are alike in form, though not equal. 49. Therefore similar figures or bodies are to each other in proportion to their respective areas or bulks. 50. The line or space on which a figure stands is called its base; its altitude is determined by a line drawn parallel to its base, and touching its vertex, or highest part. 51. A right-lined figure is said to be inscribed within another, when all its projecting angles are touched thereby. 52. The figure surrounding or enveloping another is said to be described around, or on it. 53. When a line touches a circle, and proceeds without cutting it, such line is called a tangent. 54. Any portion less than a semicircle, taken out from a circle by two lines, or radii, proceeding from the centre, is called a sector.

Certain Axioms are likewise proper to be carried in mind; *viz.* 1. That things equal to one and the same thing are equal to one another. 2. If to equal things (or numbers) we add equal things, (or num-

bers) the whole will be equal. 3. If from equal things we take equal things, the remainder will be equal, and the reverse in respect to unequal things. 4. The whole is greater than any of its parts. 5. Two right lines do not contain a space. 6. All the angles within a circle cannot amount to more nor less than 360 degrees, nor in a semicircle to more nor less than 180 degrees. 7. The value, or measure, of an angle is not affected or changed by the lines whereby it is formed being either lengthened or shortened. 8. Two lines standing at an angle of 90 degrees from each other will not be affected by any change of position of the entire figure in which they meet, but will still be mutually perpendicular.

After thus much preparation, we may conclude the student to be ready to proceed in the solution of problems, which we shall study to exhibit in the most simple, as well as in a progressive manner.

PROBLEM I.

To describe an equilateral triangle upon a given line. Let A B (fig. 1.) be the given line, with an opening of your compasses equal to its length: from each end, A and B, draw the arcs C D and E F, to whose point of intersection at C draw the lines A C and B C.

PROBLEM II.

To divide an angle equally. Fig. 2. Let B A C be the given angle, measure off equal distances from A to B, and from A to C; then with the opening B C draw alternately from B and from C the arcs which intersect at D: a line drawn from A to D will bisect the angle B A C.

PROBLEM III.

To bisect a given line. Fig. 3. Let A B be the given line; from each end (or nearer, if space be wanting,) with an opening of your compasses rather more than half the length of A B, describe the arcs which intersect above at C, and below at D: draw the line C D, passing through the points of intersection, and the line A B will be divided into two equal parts. Observe, this is an easy mode of erecting a perpendicular upon any given line.

PROBLEM IV.

To raise a perpendicular on a given point in a line. Fig. 4. With a moderate opening of your compasses, and placing one of its legs a little above or below the given line, describe a circle passing through the given point A on the line B C; then draw a line from the place where the circle cuts at D, so as to pass through E, the centre to F on the opposite side of the circle: the line F A will be the perpendicular required.

PROBLEM V.

From a given point to let fall a perpendicular on a given line. Fig. 5. From the given point A draw the segment B C, passing under the line D E; bisect B C in F, and draw the perpendicular A F.

THEOREM VI.

The opposite angles made by intersecting lines are equal; (fig. 6.) as is shown in this figure: *o, o,* are equal; *p, p,* are equal; *s, s,* are equal.

PROBLEM VII.

To describe a triangle with three given lines. Fig. 7. Let A B, B C, and C D, be the three given lines; assume either of them, say A B, for a base; then with an opening equal to B C, draw the segment from the point B of the base, and with the opening C D make a segment from C: the intersection of the two segments will determine the lengths of the two lines B C and C D, and of the angle A B C.

PROBLEM VIII.

To imitate a given angle at a given point. Fig. 8. Let A B C be the given angle, and O the point on the line O D whereon it is to be imitated. Draw the line A C, and from O measure towards D with an opening equal to A B: then from O make a segment with an opening equal to B C, and from K make a segment with an opening equal to A C; their intersection at E will give the point through which a line from O will make an angle with O D equal to the angle A B C.

THEOREM IX.

All right lines severally parallel to any given line are mutually parallel, as shown in

fig. 9, where A B, C D, E F, and G H, being all parallel to I K, are all parallels to each other severally.

N. B. They all make equal angles with the oblique line O P,

PROBLEM X.

To draw a parallel through a given point. Fig. 10. From the end, on any part of the given line A B, draw an oblique line to the given point C. Measure the angle made by A B C, and return another of equal measurement upon the line B C, so as to make the angle B C D equal to A B C: the line C D will be parallel to the line A B. Or, as in fig. 11, you may from any points, say C D, in the line A B, draw two semicircles of equal dimensions; the tangent E F will be parallel to A B. Or you may, according to Problem 5, draw a perpendicular from the given point to the given line, and draw another line through the given point at right angles with the perpendicular, proceeding from it to the line whose parallel was to be made, and which will be thus found. See fig. 12.

THEOREM XI.

Parallelograms of equal base and altitude are reciprocally equal. Fig. 13. The parallelogram No. 1, is rectangular: No. 2 is inclined, so as to hang over a space equal to the length of its own base; but the line A. B, which is perpendicular thereto, divides it into two equal parts; let the left half, A B E, be cut off, and it will, by being drawn up to the right, be found to fit into the dotted space A C D. This theorem might be exemplified in various modes; but we presume the above will suffice to prove its validity.

THEOREM XII.

Triangles of equal base and altitude are reciprocally equal. Fig. 14. As every parallelogram is divisible into two equal and similar triangles, it follows that the same rule answers for both those figures under the position assumed in this proposition: we have shown this by fig. 15.

PROBLEM XIII.

To make a parallelogram equal to a given triangle, with a given inclination or angle. Fig. 16. Let B A C be the given triangle, and E D F the given angle. On the line D F measure a base equal to B C, the base of the triangle. Take B G equal to half the altitude of the triangle for the altitude of the parallelogram, and set it off on the line E D. Draw F H parallel to E D, and H E parallel to D F, which will complete the parallelogram E F D H, equal to the triangle B A C.

PROBLEM XIV.

To apply a parallelogram to a given right line, equal to a given triangle, in a given right line figure. Fig. 17. Let A B be the given line to which the parallelogram is to be annexed. Let C be the triangle to be commuted, and D the given angle. Make B E F G equal to C, on the angle E B G; continue A B to E; carry on F E to K, and make its parallel H A L, bounded by F H, parallel to E A: draw the diagonal H K, and G M both through the point B; then K L, and the parallelogram B M A L will be equal to the triangle C, and be situated as desired.

PROBLEM XV.

To make a parallelogram, on a given inclination, equal to a right-lined figure. Fig. 18. Let A B C D be the right-lined figure, and F K H the given angle or inclination; draw the line D B, and take its length for the altitude, F K, of the intended parallelogram, applying it to the intended base line K M: now take half the greatest diameter of the triangle D C B, and set it off from K to M, and set off half the greatest diameter of the triangle D A B, and set it off from H to M: make G H to L M parallel to F K, and F G parallel to K H. The parallelogram F K G H will be equal in area to the figure A B C D, and stand at the given inclination or angle.

PROBLEM XVI.

To describe a square on a given line. Fig. 19. Raise a perpendicular at each end of the line A B equal to its length; draw the line C D, and the square is completed.

THEOREM XVII.

The square of the hypothenuse is equal to both the squares made on the other sides of a right-angled triangle. Fig. 20. This comprehends a number of the foregoing propositions, at the same time giving a very beautiful illustration of many. Let A B C be the given right-angled triangle; on each side thereof make a square. For the sake of arithmetical proof, we have assumed three measurements for them: viz. the hypothenuse at 5, one other side at 4, and

the last at 3. Now the square of *5* is 25. The square of 4 is 16, and the square of 3 is 9: it is evident the sum of the two last sides make up the sum of the hypothenuse's square; for 9 added to 16 make 25. But the mathematical solution is equally simple and certain. The squares are lettered as follow: B D C E, F G B A, and A H G K. Draw the following lines; F C, B K, A D, A L, and A E. We have already shown, that parallelograms and triangles of equal base and altitude are respectively equal. The two sides F B, B C, are equal to the two sides A B, B D, and the angle D A B is equal F B C: the triangle A B D must therefore be equal to the angle F B C. But the parallelogram B L is double the triangle A B D. The square G B is also double the triangle F B C: consequently the parallelogram B L is equal to the square G B. The square H C in like manner is proved to be equal to the parallelogram C L, which completes the solution. Euclid, 47th of 1st Book.

PROBLEM XVIII.

To divide a line, so that the rectangle contained under the whole line and one segment be equal to the square of the other segment. Fig. 21. On the given line A B describe the square A B C D; bisect A C in E, and with the distance E B extend A C to F, measuring from E. Make on the excess F A the square F H, and continue G H to K. The square F H will be equal to the parallelogram H D.

PROBLEM XIX.

To make a square equal to a given right-lined figure. Fig. 22. Let A be the given right-lined figure: commute it to a parallelogram, B D, as already shown, (prob. 15.): add the lesser side E D to B E, so as to proceed to F: bisect B F in G, and from that point describe the semicircle B H F. Continue D E to H, which will give H E for the side of a square equal in area to the parallelogram B D, and to the original given figure A.

PROBLEM XX.

To find the centre of a given circle. Fig. 23. Draw at pleasure the chord A B, bisect it in D by means of a diameter, which being bisected will give F for the centre of the circle.

PROBLEM XXI.

To complete a circle upon a given segment. Fig. 24. Let A B C be the given segment: draw the line A C, and bisect it in D; draw also the perpendicular B E through D, draw B A, and on it make the angle B A E, equal to D B A; this will give the point of intersection E for the centre, whence the circle may be completed. It matters not whether the segment be more or less than a semicircle.

PROBLEM XXII.

To cut a given circumference into two equal parts Fig. 25. Draw the line A B, bisect in C; the perpendicular D C will divide the figure into two equal and similar parts.

PROBLEM XXIII.

In a given circle to describe a triangle equiangular to a given triangle. Fig. 26. Let A B C be the circle, and D E F the triangle given. Draw the line G H, touching the circle in A: make the angle H A C equal to D E F, and G A B equal to D F E: draw B C, and the triangle B A C will be similar to the triangle D E F.

PROBLEM XXIV.

About a given circle to describe a triangle similar to a given triangle. Fig. 27. Let A B C be the given circle, and D E F the given triangle: continue the line E F both ways to G and H, and having found the centre K, of the circle, draw a radius, K B, at pleasure; then from K make the angle B K A equal to D E C, and B K C equal to D F H; the tangents L N perpendicular to K C, M N perpendicular to K B, and M L perpendicular to K A, will form the required triangle.

PROBLEM XXV.

To describe a circle about a given triangle. Fig. 28. In the given triangle A B C, bisect any two of the angles; the intersection of their dividing lines, B D and C D, will give the centre D, whence a circle may be described about the triangle, with the radius D C.

PROBLEM XXVI.

To inscribe a circle in a given triangle. Fig. 29. In the triangle A B C, divide the angles A B C, and B C A, equally by the lines B D, C D. Their junction at D will give a point whence the circle E C F may be described, with the radius D F perpendicular to B C.

PROBLEM XXVII.

To inscribe a square in a given circle. Fig. 30. Draw the diameter A C, and perpendicular thereto, the diameter B D: the lines AB, BC, CD, and DA, will form a correct square.

PROBLEM XXVIII.

To describe a circle around a square. Fig. 30. In the square ABCD, draw the diagonals AC, BD, their intersection at E will give the centre of a circle, whose radius may be any one of the four converging lines; say EA, that will enclose the square.

PROBLEM XXIX.

To describe a circle within a given square. Fig. 31. Divide the square into four equal parts, by the lines AC, BD, whose intersection, at E, shows the centre of a circle to be drawn with any one of the converging lines, say EA, as a radius.

PROBLEM XXX.

To describe a square on a given circle. Fig. 31. Divide the circle into four equal parts, (or quadrants) by the lines AC, BD; draw the tangents GH, FK, parallel to AC, and GF, HK, parallel to BD; which will give the required square.

PROBLEM XXXI.

To make an isosceles triangle, having each of the angles at the base double that at the summit. Fig. 32. Cut any given line, as AB, into extreme and mean proportions, (as in Problem 18); then, from A, as the centre, draw a circle BDE, with the opening AB, and apply the line BD within its circumference, equal to AC, the greater portion of AB; join CD, ABD will be the isosceles triangle sought.

PROBLEM XXXII.

To describe a regular pentagon. Fig. 33. Make the isosceles triangle ACD within the circle ABCDE; the base CD will give the fifth part of the circumference.

PROBLEM XXXIII.

To describe a regular pentagon about a circle. Fig. 33. This is done by drawing parallels to the lines AB, BC, CD, DE, EA; making them all tangents to the circle; on the same principle, a square, a hexagon, &c. may be drawn around a circle, from a similar figure inscribed within it.

PROBLEM XXXIV.

To describe a circle around a pentagon. Fig. 33. Bisect any two angles of a pentagon, and take their point of intersection, G, as a centre, using either of the converging lines, DG, or EG, for a radius. Where a circle is to be described within a pentagon, you must bisect any two of the faces, and raise perpendiculars at those points, which will meet in the centre either of the converging lines serving for a radius.

PROBLEM XXXV.

To inscribe a regular hexagon within a circle. Fig. 34. The radius of a circle being equal to one-sixth of its circumference, establishes a very easy mode of setting off the six sides as follows: draw the diameter AB, set one leg of your compasses at A, and draw the segment DF, and from B draw the segment CE; thus dividing the circle into six equal portions; draw lines joining them, and the figure will be complete.

PROBLEM XXXVI.

To form a quindecagon, or figure of 15 *equal sides, within a circle.* An equilateral triangle being inscribed within a circle, by assuming the distance between three points of a hexagon, say from A to C in the last figure, for a side, let one point of such triangle be applied to each angle of a pentagon in succession; its two other points will divide the opposite sides in three equal parts, as the figure changes place within the pentagon.

PROBLEM XXXVII.

To change a circle to a triangle. Fig. 35. Draw the tangent AB equal to three and one seventh diameters AD of the circle, and from the centre C draw CB, and CA: the triangle CAB will be equal in contents to the circle AD.

PROBLEM XXXVIII.

To change a pentagon into a triangle. Fig 36. Continue the base line AB to C, and from the centre D let a perpendicular fall on AB, bisecting it in E. Measure from B a space equal to four times EB. Through the centre D draw DF, parallel

and equal to EC; draw FC: the parallelogram contained under ECDF will equal the area of the pentagon. Or the pentagon may be changed to a triangle by adding to AB four times its own length, and drawing a line from the centre, to the produced termination of AB; the angle at the centre would then be obtuse.

PROBLEM XXXIX.

To draw a spiral line from a given point. Fig. 37. Draw the line AB through the given point C, and from C draw the semicircle DE, and then shift to D for a centre, and make the semicircle AE in the opposite side of the line: shift again from D to C for a centre, and draw the semicircle FG; and then continue to change the centres alternately, for any number of folds you may require; the centre C serving for all above, the centre D for all below, the line AB.

With respect to the application of geometry to its pristine intent, namely, the measurement of land, we must refer our readers to SURVEYING; under which head it will be found practically exemplified. We trust sufficient has been here said to show the utility and purposes of this important science, and to prove serviceable to such persons as may not have occasion for deep research, or for extensive detail.

GEORGIC, a poetical composition upon the subject of husbandry, containing rules therein, put into a pleasing dress, and set off with all the beauties and embellishments of poetry.

GEORGINA, in botany, a genus of the Syngenesia Superflua class and order. Receptacle chaffy; no down; calyx double; the outer many-leaved; inner one-leaved, eight-parted. There are three species.

GERANIUM, in botany, *crane's bill*, a genus of the Monadelphia Decandria class and order. Natural order of Gruinales. Gerania, Jussieu. Essential character: calyx five-leaved; corolla five-petalled, regular; nectary five honied glands, fastened to the base of the longer filaments; fruit five-grained, beaked; beaks simple, naked, neither spiral nor bearded. There are thirty-two species. There are five species indigenous to the United States. The root of one of these, G. maculatum, or spotted crane's bill, is an astringent, and the decoction of it, made with milk, is useful in cholera infantum.

GERARDIA, in botany, so called in honour of John Gerarde, our old English botanist, a genus of the Didynamia Angiospermia class and order. Natural order of Personatæ. Scrophulariæ, Jussieu. Essential character: calyx five-cleft; corolla two-lipped, lower lip three-parted, the lobes emarginate, the middle segments two-parted; capsule two-celled, gaping. There are ten species.

GERMINATION. When a seed is placed in a situation favourable to vegetation, it very soon changes its appearance; the radicle is converted into a root, and sinks into the earth; the plumula rises above the earth, and becomes the trunk or stem. When these changes take place, the seed is said to germinate; the process itself has been called germination, which does not depend upon the seed alone; something external must affect it. Seeds do not germinate equally and indifferently in all places and seasons; they require moisture and a certain degree of heat, and every species of plant seems to have a degree of heat peculiar to itself, at which its seeds begin to germinate; air also is necessary to the germination of seeds; it is for want of air, that seeds which are buried at a very great depth in the earth either thrive but indifferently, or do not rise at all. They frequently preserve, however, their germinating virtues for many years within the bowels of the earth; and it is not unusual, upon a piece of ground being newly dug to a considerable depth, to observe it soon after covered with several plants, which had not been seen there in the memory of man. Were this precaution frequently repeated, it would perhaps be the means of recovering certain species of plants which are regarded as lost; or which, perhaps, never coming to the knowledge of botanists, might hence appear the result of a new creation. Light is supposed to be injurious to the process, which affords a reason for covering the seeds with the soil in which they are to grow, and for carrying on the business of malting in darkened apartments, malting being nothing more than germination, conducted with a particular view.

GEROPOGON, in botany, a genus of the Syngenesia Polygamia Æqualis class and order. Natural order of Compositæ Semiflosculosæ, or compound flowers, with semi-florets or ligulate florets only. Cichoraceæ, Jussieu. Essential character: calyx simple; receptacle with bristle-shaped chaffs; seeds of the disk with a feathered down of the ray, with five awns. There are three species.

GESNERIA, in botany, so named in honour of Conrad Gesner, of Zurich, the famous botanist and natural historian, a genus of the Didynamia Angiospermia,

class and order. Natural order of Personatæ. Campanulaceæ, Jussieu. Essential character: calyx five-cleft, sitting on the germ; corolla incurved and recurved; capsule inferior, two-celled. There are twelve species.

GETHYLLIS, in botany, a genus of the Hexandria Monogynia class and order. Natural order of Spathaceæ. Narcissi, Jussieu. Essential character: calyx none; corolla six-parted; berry club-shaped; radicle, one-celled. There are four species.

GEUM, in botany, English *avens*, or *herb bennet*, a genus of the Icosandria Polygynia class and order. Natural order of Senticosæ. Rosaceæ, Jussieu. Essential character: calyx ten-cleft; petals five; seeds with a kneed awn. There are nine species, natives of Europe and North America; seven belonging to North America.

GHINIA, in botany, so named in memory of Lucas Ghini, a famous physician and botanist of Bologna, a genus of the Diandria Monogynia class and order. Natural order of Personatæ. Vitices, Jussieu. Essential character: calyx five-toothed, teeth acuminate; corolla two-lipped; stamina four, with two barren anthers at the end of the shorter filaments; pericarpium a drupe containing four or five celled nuts, with a seed in each cell. There are two species.

GIANT's *causeway*, a vast collection of a black kind of marle, called basaltes, in the county of Antrim in Ireland. See Basaltes, and Staffa.

GIBBOUS, in astronomy, a term used in reference to the enlightened parts of the moon, whilst she is moving from the first quarter to the full, and from the full to the last quarter: for all that time the dark part appears horned, or falcated; and the light one hunched out, convex or gibbous.

END OF VOL. V.

Fig. 1. Castor *fiber: beaver* – *Fig. 2.* Cavia *cobaya: guinea pig* – *Fig. 3.* C. *paca spotted cavy* – *Fig. 4.* C. *aguti: long nosed cavy* – *Fig. 5.* Dasypus *sexcinctus six banded armadillo* – *Fig. 6.* D. *novemcinctus: nine banded armadillo.*

Fig.1. Didelphis *maculata : spotted opossum _ Fig.2.* D. *volans : flying opossum Fig.3.* D. *gigantea kanguroo _ Fig.4.* D. *tridactyla : kanguroo rat _ Fig.5.* Dipus *jaculus: common jerboa _ Fig.6.* D. *canadensis : canada jerboa.*

MAMMALIA.

Plate. X.

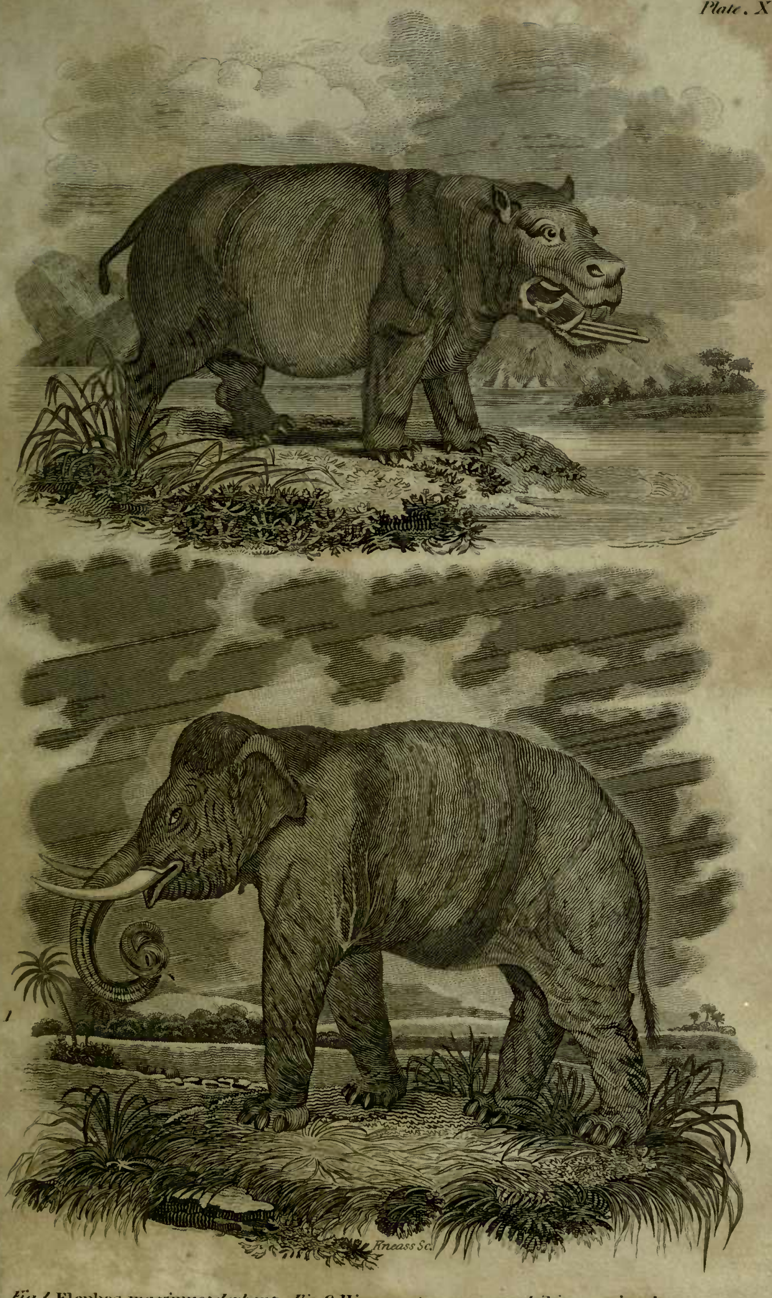

Fig. 1. Elephas *maximus: elephant* _ *Fig. 2.* Hippopotamus *amphibius; river horse*.

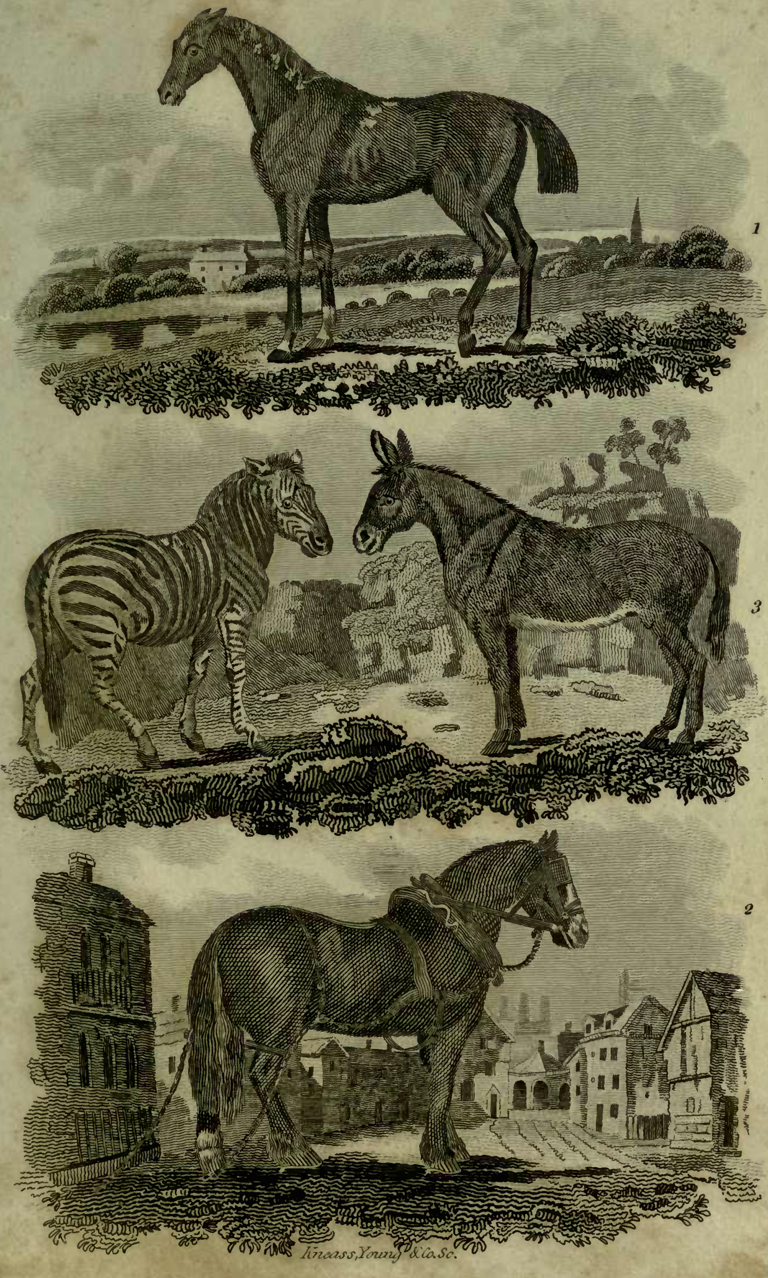

Fig. 1. Equus *caballus : Race Horse _ Fig. 2. Cart Horse _ Fig. 3.* E. *asinus : Mule*
Fig. 4. E. *zebra : Zebra.*

5

Fig. 1. Erinaceus *Europæus: Common Hedge hog – Fig. 2.* E. *Malaccensis: Malacca hedge hog – Fig. 3.* Hystrix *cristata: Crested Porcupine – Fig. 4.* H. *prehensilis: Brasilian Porcupine – Fig. 5.* Hyrax *capensis: Cape Hyrax.*

Kneass Sc.

Felis *Leo: Lion, Lioness and Whelps.*

Fig. 1. Felis *Leopardus : Leopard _ Fig. 2. F. Pardus : panther*
Fig. 3. F. Tigris : Tiger _ Fig. 4. F. Lynx.

Fig. 1. Cuculus *canorus: cuckoo* _ *Fig. 2.* Didus *ineptus: hooded dodo* _ *Fig. 3.* Diomedea *exulans: wandering albatross* _ *Fig. 4.* Emberiza *cirlus: cirl bunting* _ *Fig. 5.* F. *hyemalis: black headed bunting* _ *Fig. 6.* Fringilla *carduelis: goldfinch* _ *Fig. 7.* F. *linaria: lesser red pole* *Fig. 8.* F. *montana tree sparrow.*

DRAWING.

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ENTOMOLOGY.

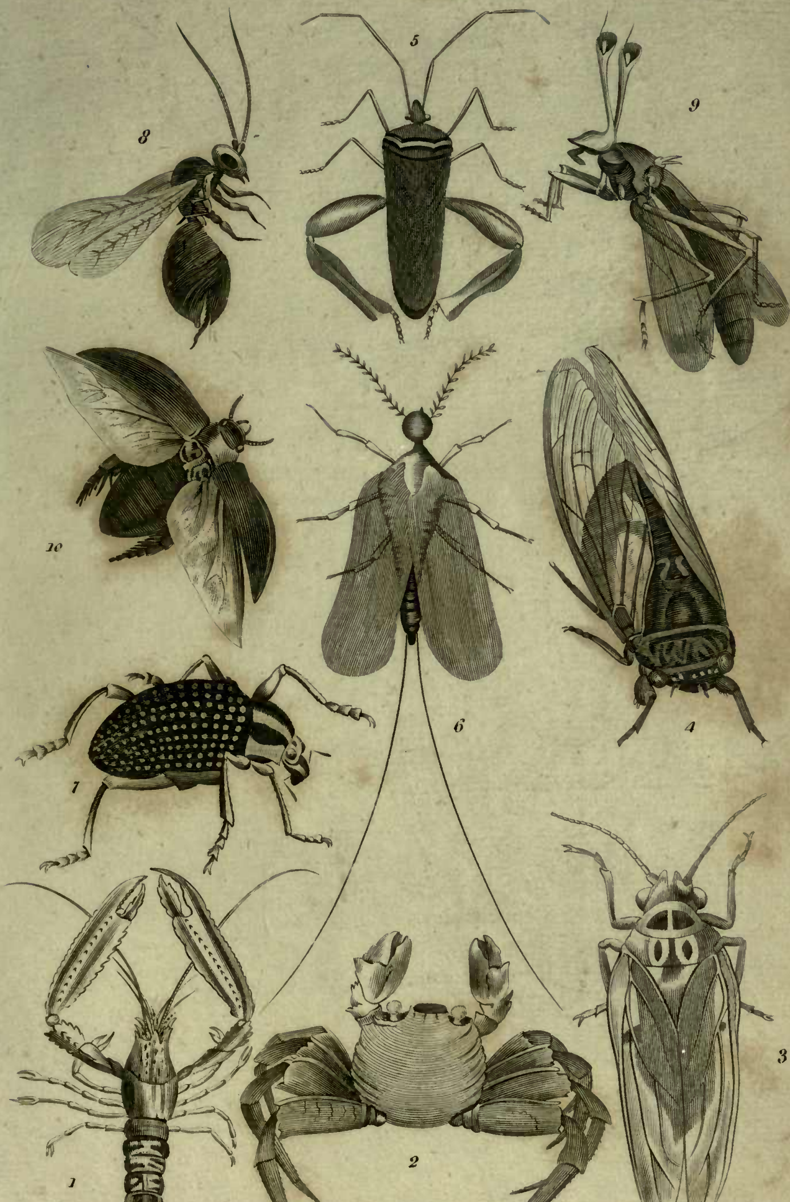
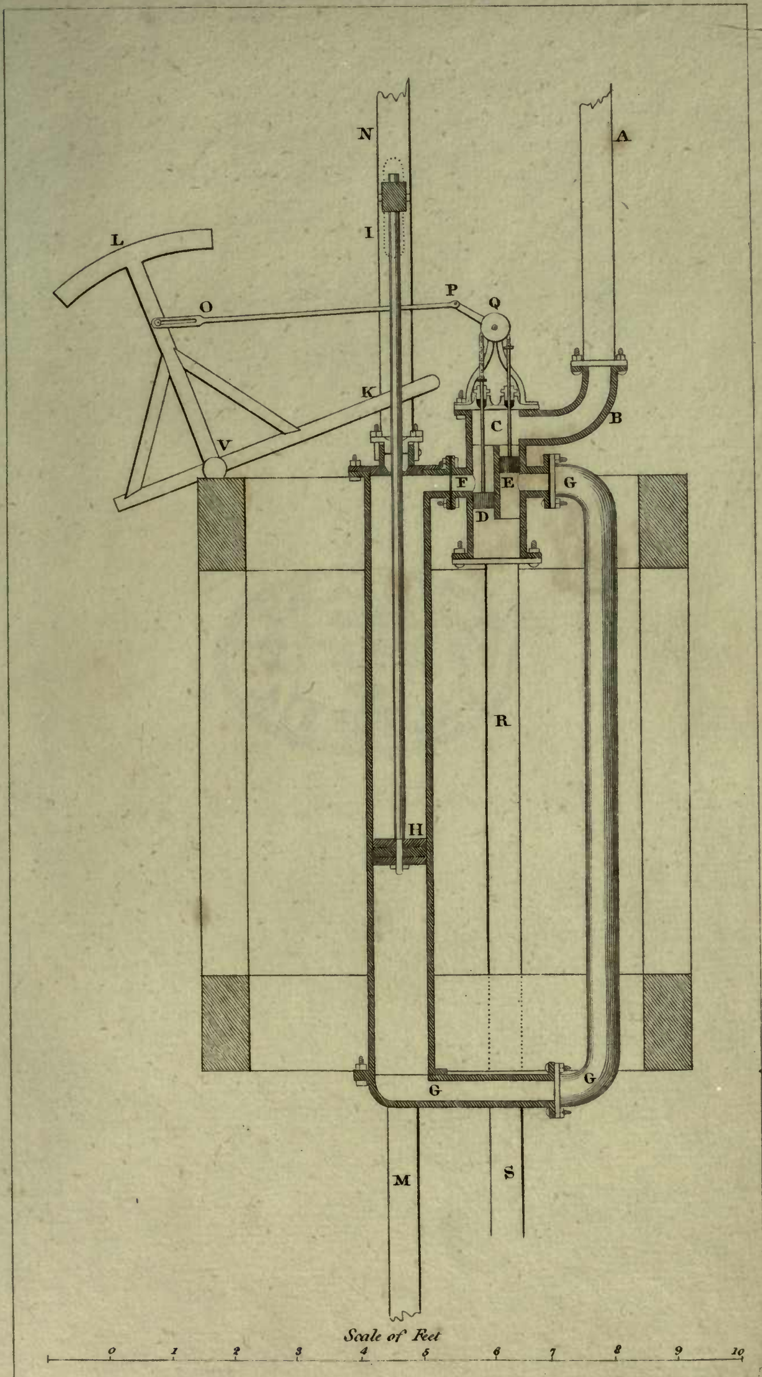


Fig. 1. Cancer *norvegicus: norway crab* – *Fig. 2.* C. *grapsus: streaked crab* – *Fig. 3.* Chermes *pyri* – *Fig. 4.* Cicada *plebia* – *Fig. 5.* Cimex *latipes* – *Fig. 6.* Coccus *cacti* – *Fig. 7.* Curculio *imperialis: diamond beetle* – *Fig. 8.* Cynips *rosæ* – *Fig. 9.* Diopsis *ichneumon* – *Fig. 10.* Dytiscus *marginalis.*

Mr. R. TREVATHICK'S PRESSURE ENGINE.
erected at the Druid Copper Mine, Cornwall.



Fenner Sc.

ROWNTREE'S FIRE ENGINE.

Elevations.

Fig. 1.

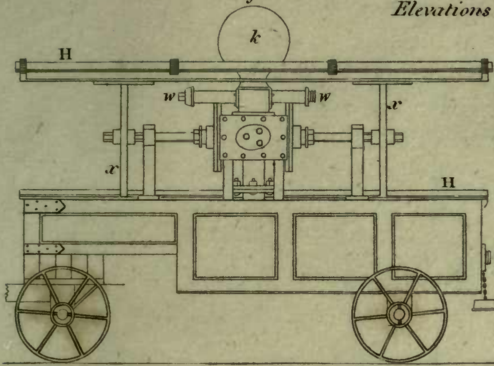
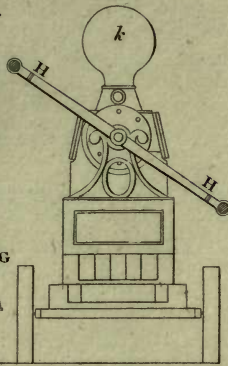


Fig. 2.



Sections.

Fig. 3.

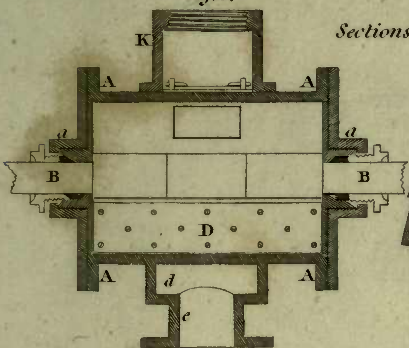
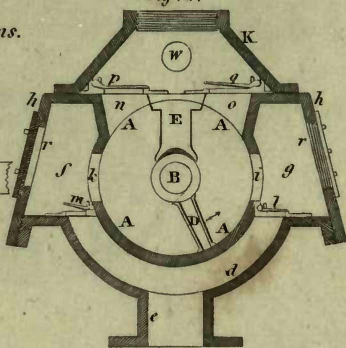


Fig. 4.



Elevation of the suction Pipe.

Fig. 5.

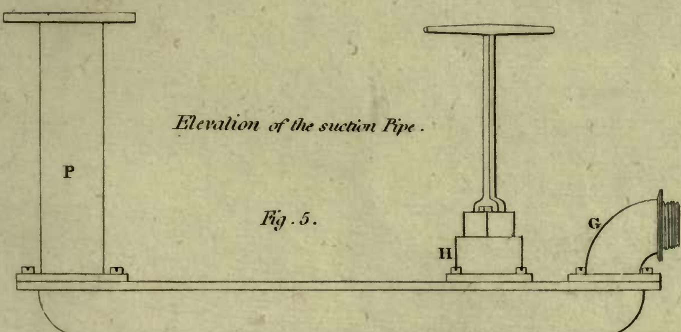
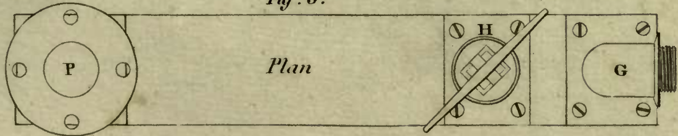


Fig. 6.



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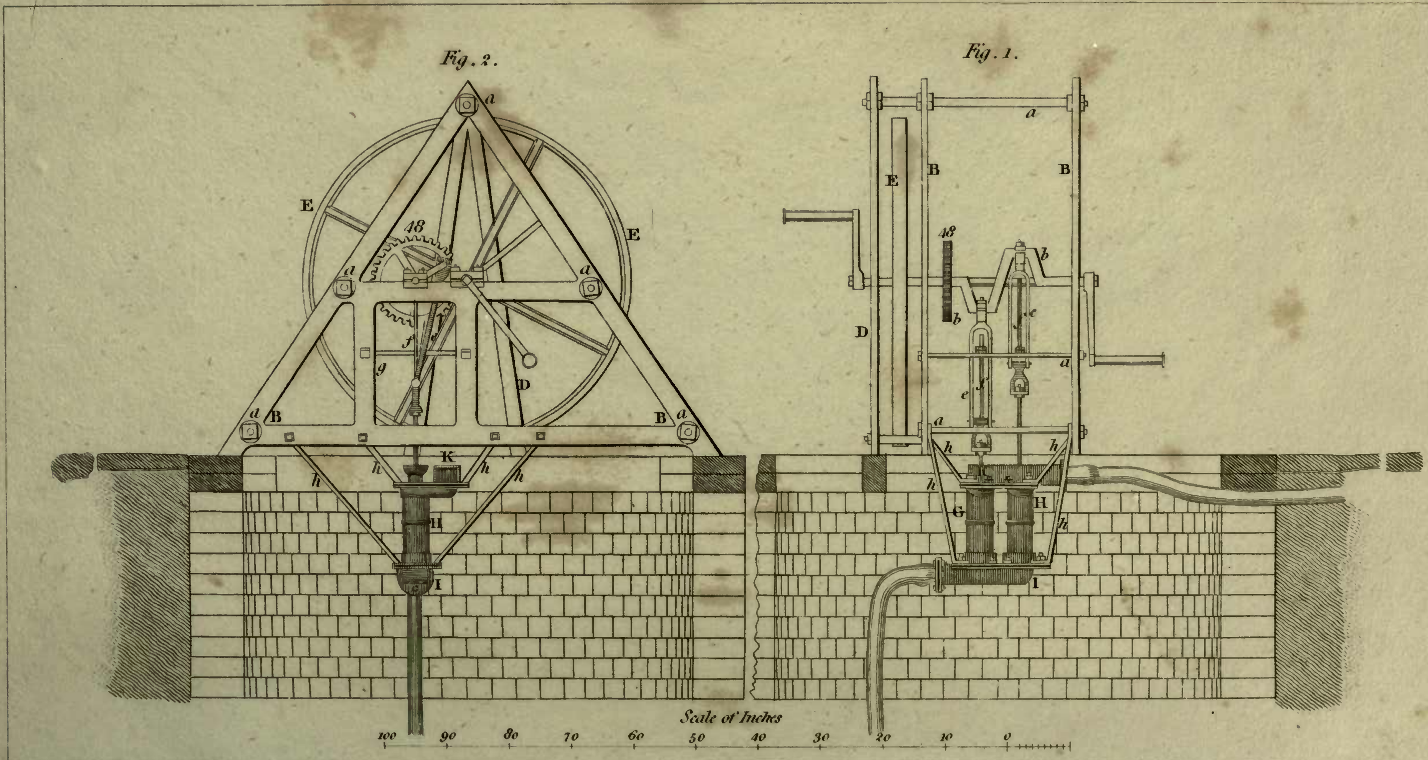
A double Barreled Hand Pump Engine, by Mr. Rowntree.



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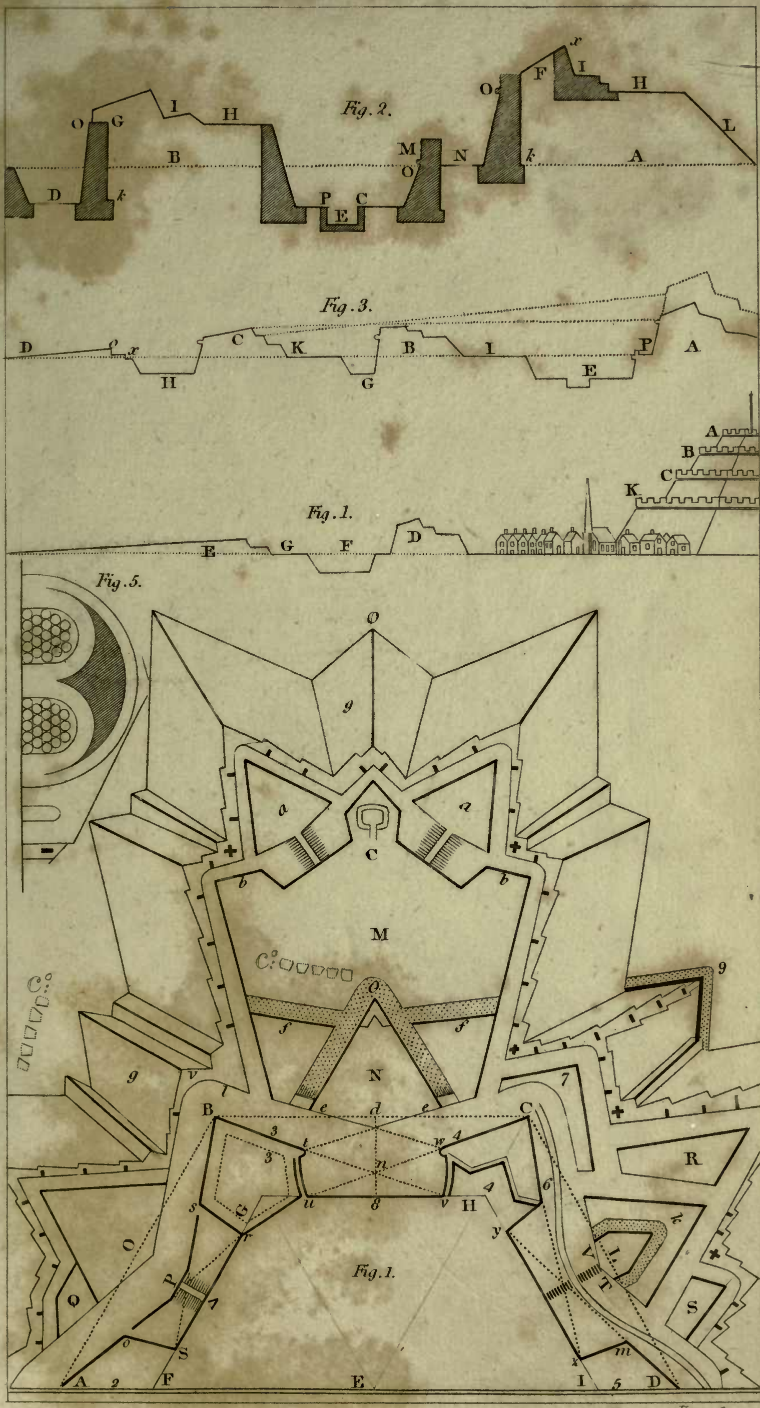
FORTIFICATION.



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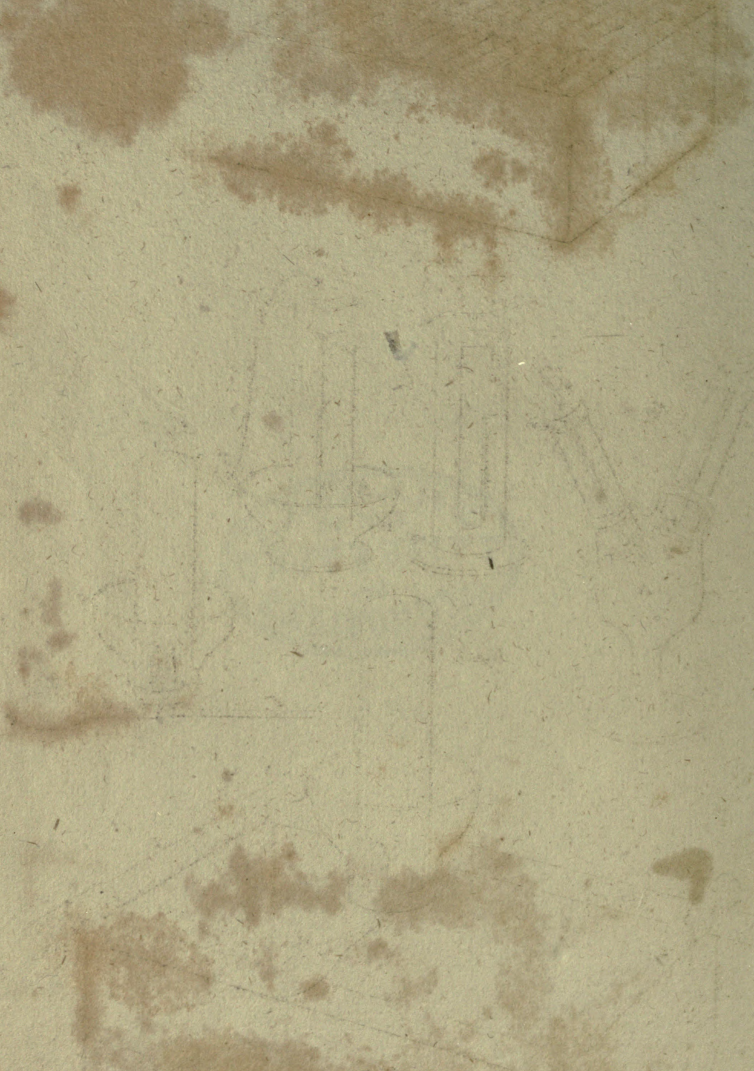


GALVANISM.

Fig. 1.

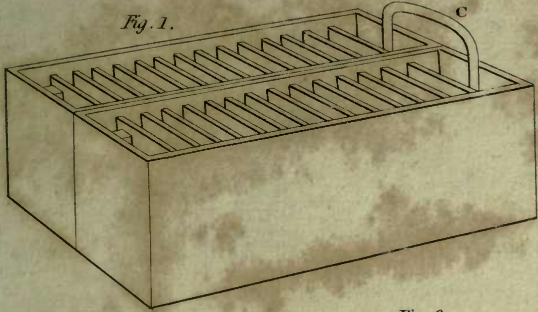


Fig. 2.

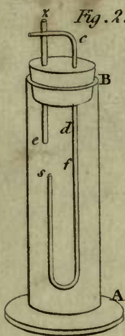


Fig. 3.

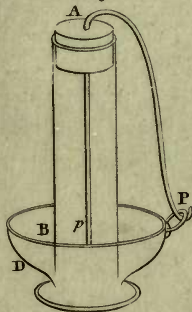


Fig. 6.

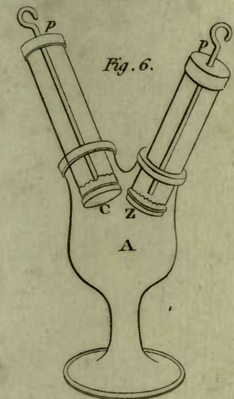


Fig 4

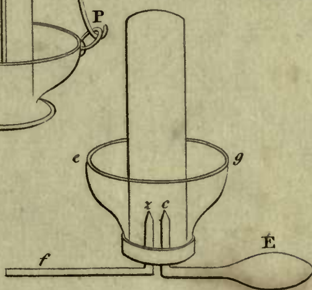
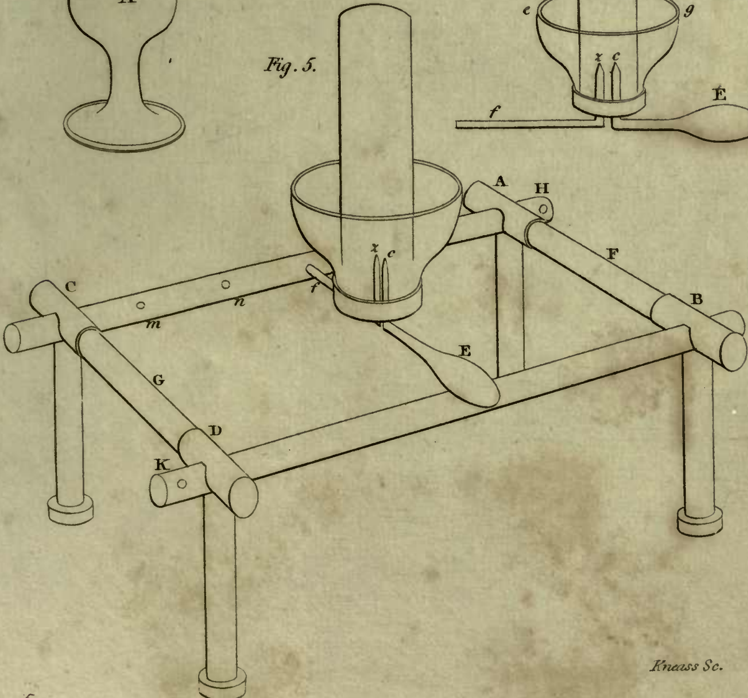


Fig. 5.



Kneass Sc.